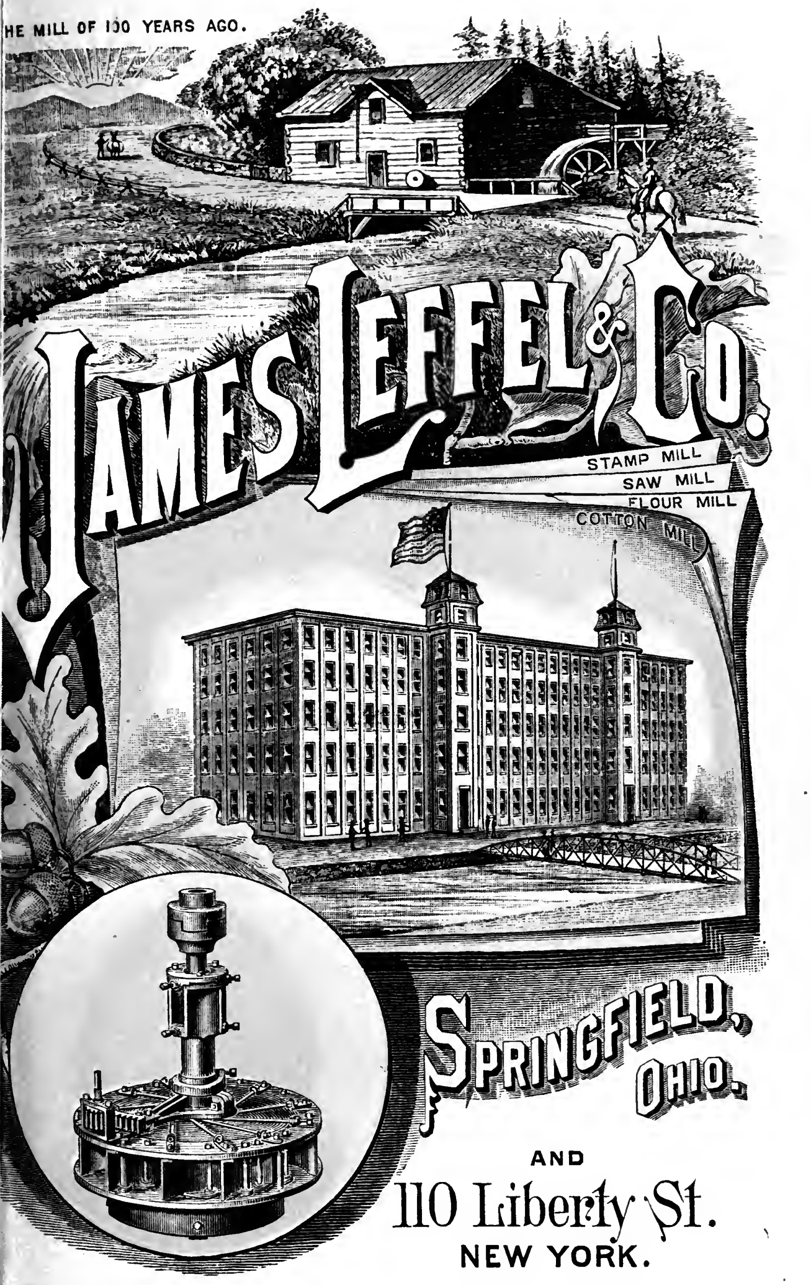
THE MILL OF 100 YEARS AGO.
JAMES LEFFEL & CO.
STAMP MILL
SAW MILL
FLOUR MILL
COTTON MILL
SPRINGFIELD,
OHIO.
AND
110 Liberty St.
NEW YORK.

ILLUSTRATED HAND BOOK

—OF—

JAMES LEFFEL'S

—IMPROVED—

DOUBLE TURBINE WATER WHEEL

FOR 1885 AND 1886.

FOR PARTICULARS, APPLY TO

JAMES LEFFEL & CO.,

MANUFACTURERS,

SPRINGFIELD, OHIO.

—AND—

110 LIBERTY STREET, NEW YORK CITY.

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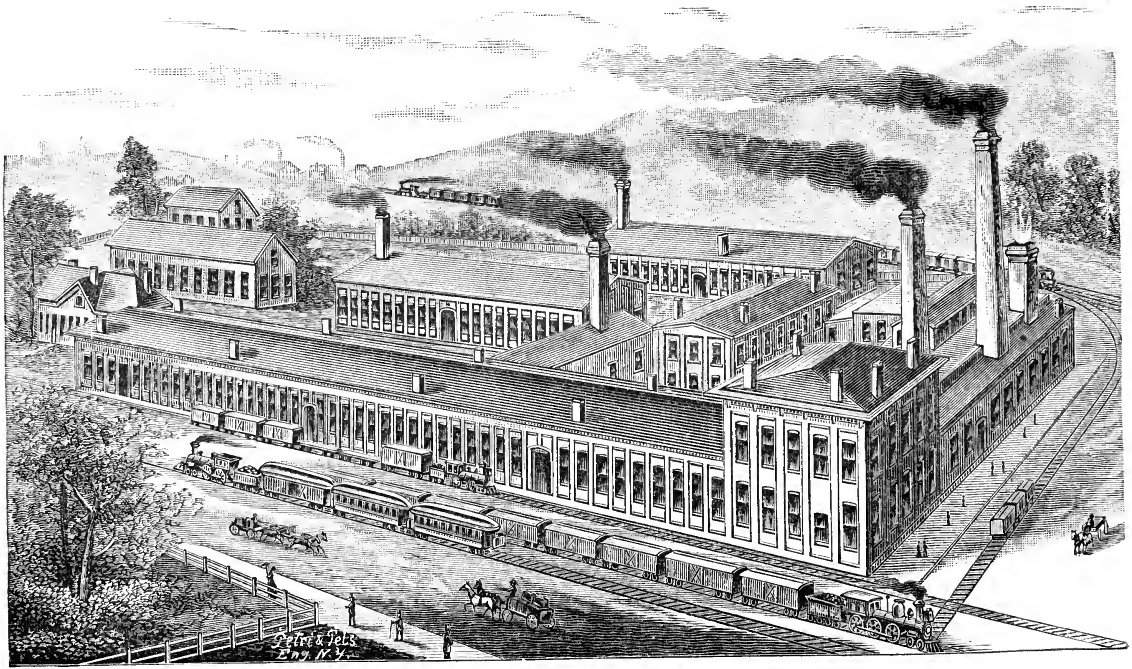


New Water Wheel Works of James Leffel & Co., Springfield, Ohio.

INTRODUCTION.

A reputation which endures and increases with the progress of time, and after the lapse of twenty-three years, is more widely and firmly established than ever before, cannot but be founded upon superior merit. This is the history, in few words, of the James Leffel Double Turbine Water Wheel. No other testimony can be so convincing in this regard as the acts and words of the users of the Wheel. They are judges of whose competency there can be no doubt, and the successful operation of the Wheel in their hands, under the most trying and varied circumstances, has elicited such fervent praise from them as nothing but the highest degree of excellence could command. We give in this volume a few, and only a few, of these enthusiastic letters. To publish them all would fill a much larger book than this, to the entire exclusion of all other matter; but those here printed will convey some idea of the estimate placed upon the Wheel by those who have it in use.

The popularity of the Leffel Wheel and its increasing sale have led to the erection by us of new, large and commodious works, fitted throughout with the most improved and expensive labor-saving machinery, especially made for and adapted to the proper manufacture of the various parts of the Leffel Wheel. We are enabled by means of this special machinery to produce at the very lowest cost a Wheel, which cannot be surpassed either in the practical excellence of its design or in the accurate formation and adjustment of its parts. Such improvements in the Wheel are made from time to time as the growth of mechanical science and the developments of manufacturing industry show to be feasible and useful; and it is thus maintained in its position as the most finished and perfect product of inventive skill to be found in this class of motors.

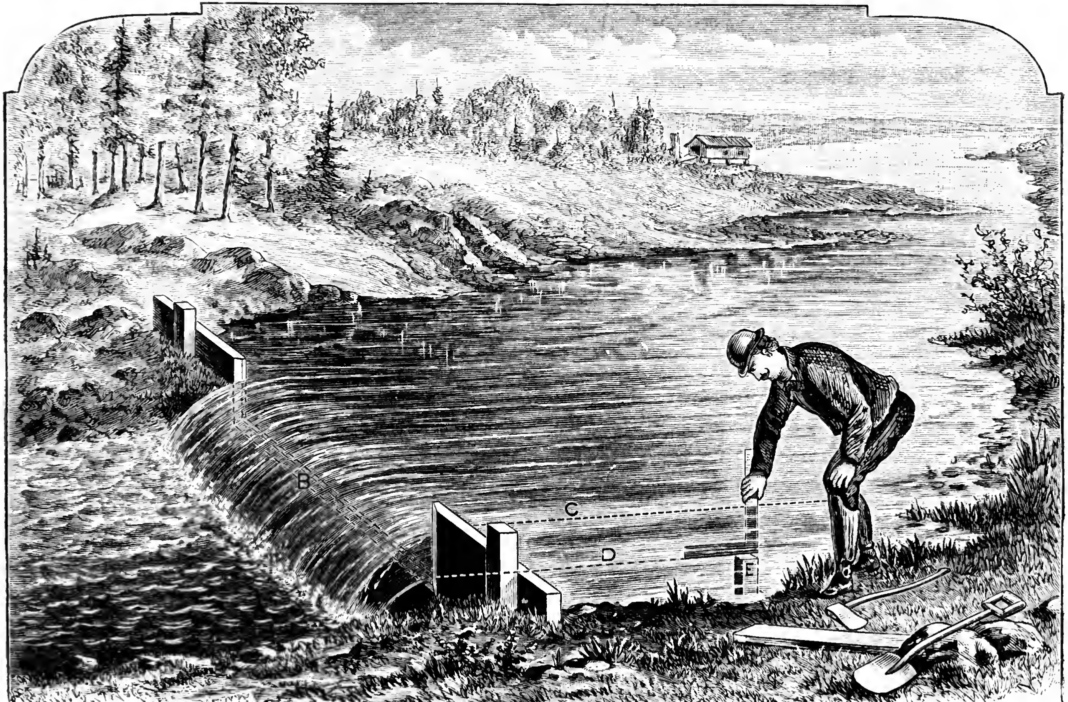
The present edition of our Wheel Book is issued in the same convenient and we believe not less attractive form than those preceding it, and contains matter which will be found of the highest practical utility. Users of water power in all parts of the world have come to regard the Leffel Wheel Book as an almost indispensable manual, and the frequent requests for it have rendered this new issue necessary. In addition to the recent valuable improvements in the Wheel, together with the reduced prices at which it is sold, we include in this volume a large variety of practical information upon subjects of importance to every owner or user of water power. Desiring not only to extend our business, but also to serve the interests of those to whom this work is addressed, we have sought to render it worthy of attentive perusal and careful preservation.

JAMES LEFFEL & CO.

MEASUREMENT OF WATER.

When a man has concluded to improve a water power, the first thing he should ascertain is the amount of head and fall he can secure. The next, and most important step, is to determine accurately the quantity of water that flows in the stream, (provided there is a limited supply,) as upon this will depend the amount of power, and consequently the amount of work, the stream is capable of performing. And as the improvement of water power is necessarily attended with expense, it is therefore important to one who contemplates building a mill or factory, that he should know exactly what amount of work he can depend upon the stream doing; as for the want of an accurate knowledge, or from an erroneous supposition of the quantity of water in the stream, parties frequently construct mills and factories of a magnitude which, upon trial, is found to be entirely out of proportion to the power of the stream, and it fails to drive their machinery. Such being often the case, it is important, when practicable, to get some one well versed in hydraulics to measure the capacity of the stream. As this cannot always be done, we give herewith a few plain suggestions and illustrations, by the aid of which any one can determine approximately the quantity of water in a stream.

The plate represents a weir dam across a small stream. Where it is convenient to use a single board, as shown in the cut, select one that is long enough to reach across the stream, resting in the bank at each end. Cut a notch in the board sufficient in depth to pass all the water to be measured, and not more than two-thirds of the width of the stream in length. The bottom of notch B in the board A should be beveled on the down stream side; the ends of the notch should also be beveled on the same side, and within one-eighth of an inch of the upper side of the board, leaving the edge almost sharp. E is a stake driven in the bottom of stream several feet above the board or dam, and should be driven down to the level of notch B, this level being easily found as the water is beginning to spill over the board. After the water has come to a stand and reached its greatest depth, a careful measurement can be made of the depth of water over the top of stake E, as illustrated in the cut by the man with square and measure in his hand. Such measurement gives the true depth of water passing over the notch, since, if measured directly on the notch or the board, the curvature of the water in passing would reduce the depth, giving the improper measure. Although, where accuracy is not required, such a method will give a fair estimate of the quantity of water, in all cases it is best to make the measurement over the stake. The line D is a level from the bottom of notch B to the top of stake E; while the dotted line C represents the top of the water, and the distance between the lines from the top of stake, give the true depth or spill over the weir. The lines have in the cut, the appearance of running over the top of the board; but this is owing to the fact that they pass behind it, and, for the purpose of illustration, the reader


B
C
D
E

is supposed to look through the board and the post. The surface of the water below the board should not be nearer the notch B than ten inches, that the flow of water over the notch may not be impeded. Neither should the nature of the channel above the board be such as to force or hurry the water to the board, but it should be of ample width and depth to allow the water to approach the notch and board steadily and quietly. If the water passes the channel rapidly it will be forced over the notch, and a larger quantity will pass than if allowed to spill from a large body moving slowly.

When the depth of water over the stake E is known, the quantity of water passing can be easily calculated by reference to the Weir Table on page 7. This table gives the number of cubic feet of water passing per minute over a weir for each inch in breadth, from one-sixteenth of an inch in depth to twenty-five inches in depth. The figures 1, 2, 3, etc., in the first and last perpendicular columns, are the inches depth of water over weir, while the first or top horizontal column represents fractional parts of an inch, from one-sixteenth to sixteen sixteenths. The body of table shows the cubic feet that will pass each minute for each depth of weir, from one-six-teenth to twenty-five inches, as before stated. But each result is for but one inch in width ; so, for any particular number of inches breadth of weir the result obtained in table must be multiplied by the number of inches of breadth the weir may be. For example suppose the notch or weir be 20 inches wide, and the water at stake E 5½ inches deep ; in the first or last column find the figure 5, follow the horizontal column until the perpendicular column is reached containing ½ at the top. In the square where these two columns meet will be found 5.18 (five and eighteen hundredths) cubic feet. This is the quantity of water that will pass for each inch, in width ; but, since the supposed weir was 20 inches wide, this result must be multiplied by 20, which gives 103.60 (one hundred and three and six-tenths) cubic feet per minute. In this manner the water passing any width of weir, of any depth from one-sixteenth of an inch to twenty-five inches depth, can be easily calculated.

A very important matter in connection with the measurement of small streams is also the possibility of damming or holding the water, and using it a part of the time instead of constantly. If the above mentioned quantity of water was held for twelve hours, for the remaining twelve hours (if all was used in that time) double the quantity would be available, and consequently double the power obtained for that length of time. The power is thus stored up to be used in less time, besides giving a better effect, since with a small quantity of water, almost as much power is required to drive the necessary machinery without labor as when driving at labor. Now, while this whole method may appear simple, we would always like as full an understanding of all the circumstances as possible however confident parties may be of the accuracy of their measurements.

We, therefore, particularly request our correspondents, in writing

WEIR TABLE FROM ONE-SIXTEENTH INCH DEPTH TO TWENTY-FIVE INCHES DEPTH.

Inches		1/16	1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	11/16	3/4	13/16	7/8	15/16		Inches
		.006	.01	.03	.05	.07	.09	.11	.14	.17	.20	.23	.26	.30	.33	.36		
1	.40	.43	.47	.51	55	.60	.65	.70	.74	.78	.83	.87	.93	.98	1.03	1.08	.40	1
2	1.14	1.19	1.24	1.30	1.36	1.41	1.47	1.52	1.59	1.65	1.71	1.77	1.83	1.89	1.96	2.02	1.14	2
3	2.09	2.16	2.23	2.29	2.36	2.43	2.50	2.57	2.63	2.71	2.78	2 85	2.92	2.99	3.07	3 14	2.09	3
4	3.22	3.29	3.37	3.44	3.52	3.60	3.68	3.75	3.83	3.91	3.99	4.07	4.16	4.24	4.32	4.41	3.22	4
5	4.50	4.58	4.67	4.75	4.84	4.92	5 01	5.10	5.18	5.27	5.36	5.45	5.54	5.63	5.72	5.81	4.50	5
6	5.90	6.00	6.09	6.18	6.28	6.37	6.47	6.56	6.65	6.75	6.85	6.95	7.05	7.15	7.25	7.35	5.90	6
7	7.44	7.54	7.64	7.74	7.84	7.94	8.05	8.15	8.25	8.35	8.45	8.55	8.66	8 76	8.86	8.97	7.44	7
8	9.10	9.20	9.31	9.42	9.52	9.63	9.74	9.85	9.96	10.07	10.18	10.29	10.40	10 51	10.62	10.73	9.10	8
9	10.86	10.97	11.08	11.19	11.31	11.42	11.54	11.65	11.77	11.88	12.00	12.12	12.23	12.35	12.47	12.59	10.86	9
10	12.71	12.83	13.95	13.07	13.19	13.31	13.43	13.55	13.67	13.80	13.93	14.04	14.16	14.30	14.42	14.55	12.71	10
11	14.67	14.79	14.92	15.05	15.18	15.30	15.43	15.56	15.67	15.81	15.96	16.08	16.20	16.34	16.46	16.59	14.67	11
12	16.73	16.86	16.99	17.12	17.26	17.39	17.52	17.65	17.78	17.91	18.05	18.18	18.32	18.45	18.58	18.72	16.73	12
13	18.87	19.01	19.14	19.28	19.42	19.55	19.69	19.83	19.97	20.10	20.24	20.38	20.52	20.66	20.80	20.94	18.87	13
14	21.09	21.23	21.37	21.48	21.65	21.79	21.94	22.08	22.22	22.35	22.51	22.65	22.79	22.94	23.08	23.23	21.09	14
15	23.38	23.53	23.67	23.82	23.97	24.11	24.26	24.41	24.56	24.71	24.86	25.01	25.16	25.31	25.46	25.61	23.38	15
16	25.76	25.91	26.06	26.21	26.36	26.51	26.66	26.81	26.97	27.12	27.27	27.43	27.58	27.73	27.89	28.04	25.76	16
17	28.20	28.35	28.51	28.66	28.82	28.98	29.14	29.29	29.45	29.60	29.76	29.92	30.08	30.23	30.39	30.55	28.20	17
18	30.70	30.86	31.02	31.18	31.34	31.50	31.66	31.81	31.98	32.15	32.31	32.47	32.63	32.80	32.96	33.12	30.70	18
19	33.29	33.45	33.61	33.78	33.94	34.11	34.27	34.44	34.60	34.77	34.94	35.10	35.27	35.44	35.60	35.77	33.29	19
20	35.94	36.10	36.27	34.46	36.60	37.87	36.94	37.11	37.28	37.45	37.62	37.79	37.96	38.14	38.31	38.48	35.94	20
21	38.65	38.82	39.00	39.17	39.34	39.52	39.69	39.86	40.04	40.21	40.39	40.56	40.73	40.91	41.09	41.26	38.65	21
22	41.43	41.60	41.78	41.96	42.13	42.31	42.49	42.67	42.84	43.02	43.20	43.38	43.56	43.74	43.92	44.10	41.43	22
23	44.28	44.46	44.64	44.82	45.00	45.18	45.38	45.53	45.71	45.90	46.08	46.26	46.43	46.63	46.81	47.00	44.28	23
24	47.18	47.36	47.55	47.72	47.91	48.09	48.28	48.46	48.65	48.83	49.02	49.20	49.39	49.58	49.76	49.93	47.18	24

on this subject, to give us the depth and width of the water over weir, so we can verify the calculations ourselves; state also what length of time the water can be dammed or held, if the stream is small.

For Measuring Water More Accurately.

It sometimes becomes necessary to vary the foregoing method in certain particulars, when it is desired to ascertain with great exactness the quantity of water a stream furnishes, or a wheel is using. On very small streams, or where wheels are competing, or where the useful effect or power of a wheel for the quantity of water is required with special precision, the arrangements for measuring should be more carefully prepared, and corrections made that are not taken into consideration in the foregoing description. The notch B should be made in a thin plate or sheet of iron, forming almost a sharp edge, (as a thick one retards the flow,) the plate then being screwed fast to the board, A, on its upper side; the requisite stiffness is thus afforded to the iron. The notch in the iron should be made sufficiently less in size than that in the board, both on the bottom and at each end, to enable the water to pass clear of the board at all points, its flow being thus entirely unobstructed.

If the ordinary square and measure is used, the stake, E, should be driven so that the top will be precisely level with the edge of the iron lip or notch; but since the capillary attraction caused by placing a rule in the water and on the stakes gives rise to some uncertainty in measuring by that means, it is best to use a hook gauge. In this case the stake E, stands above the level of the water to any convenient height, and is graduated with any degree of minuteness desired. The point on the stake on an exact level with the top of the notch may be fixed by means of a spirit level and straight edge. From this point to the commencement of the graduated scale, or zero, the distance is equal to the length of the gauge less the vertical length of the hook, so that when the water is just even with the notch, the top of the gauge will be at 0 on the scale, the top of the hook being at the surface of the water. Then as the water rises, the gauge is held against the stake and carefully adjusted by sliding up until the hook comes as before, exactly to the level of the surface water, when the top of the gauge will show on the scale the precise depth over the notch.

Again, the velocity of the water as it approaches the weir is a matter to be carefully considered and calculated. In the foregoing remarks we have considered the measurement of depth as though it were in still water. The nature of the channel will materially affect the approach of water to the point where it spills; the tendency being to increase the discharge over the notch. The correction for this increased discharge is made by adding to the actual depth obtained, the amount of head water that would produce the velocity. Then from this measure can be ascertained by the table the actual amount of water spilling; except that from another

cause of less consequence, but of sufficient importance to engage our notice, there is also a correction to be made, which is for the contraction to which short weirs are subject at the two ends. Weirs of all lengths, especially if narrower than the channel, are liable to this deviation or narrowing of the stream or flow of water—not, however, in so great a proportion as short ones. Experiments of a thoroughly reliable character show that this condition of the spill of water operates at both ends, and reduces the effective length of weir in about the proportion of two-tenths of an inch for each inch in depth of the spill, or one inch for each five inches depth, that is for a weir 80 inches wide and the spill 5 inches deep, the actual width to be calculated for will be 79 inches.

It rarely occurs that such exactness will be required for the measurement as is described in this article, and for all ordinary and practical purposes, the preceding article will be sufficiently accurate.

Measurement of Large Open Streams.

As in many cases it is impossible to construct even a temporary waste-board or weir, the quantity of water that the stream can supply must be obtained by first ascertaining the mean velocity in feet per minute, and also the area of cross section of the stream in square feet; when the product of these two quantities will give the required quantity of water afforded by the stream. The velocity of such stream can be estimated by throwing floating bodies on the surface of near the same specific gravity as the water, and rating the time accurately, required in passing a given distance; it must be borne in mind, however, that the velocity is greatest in the center of the stream and near the surface, and that it is less near the bottom and side. It is generally best to ascertain the velocity at the center, and from this estimate the mean velocity, which has been found by accurate and reliable experiments to be 83 per cent, or about four-fifths of the velocity of the surface. The cross section may be estimated by measuring the depth of a stream at a number of points, at equal distance apart, (these points being in a line across the stream,) adding the depths together, and multiplying their sum by the distance apart in feet of any two points. This will give the result required in square feet of cross section, when the product of mean velocity in feet per minute and cross section in square feet, obtains the quantity of water that the stream affords in cubic feet per minute.

Measurement of Water on Overshot or Breast Wheel.

Another method of obtaining the quantity of water approximately, where an overshot or breast wheel is already in use, and where it is difficult to so arrange as to obtain the quantity of water by our first or weir measurement, would be to measure in square inches the amount of opening, made by raising the gate, through which the water is to pass upon the over shot or breast wheel, giving also the depth of water over the gate opening. The length of opening made, by draw-

ing the sliding gate, as well as the thickness or width of this opening, should be carefully given. Both of these measurements are more or less accurately required, in order to ascertain as nearly as possible, the amount of opening in square inches that the gate makes; for upon the accuracy of all the measurements required, depends the degree of accuracy with which the quantity of water will be estimated by this method.

By multiplying together the length and breadth of the opening, the number of square inches of gateage or issue upon the wheel is ascertained; but in addition to these two measurements another of equal importance must be taken, viz: the depth of water from the top surface or level to the floor of Penstock or lower part of gate opening. It is the depth of water that gives the velocity with which it passes through the gate opening; consequently the quantity discharged depends upon the depth as well as opening.

An application of the measurements thus obtained may now be made to the following table of spouting revolutions, arranged for the purpose, in which the columns B represent the head or depth of water the table giving depths in inches from 1 to 40; columns E represent the velocity per second, in inches and decimals of an inch; columns F represent the number of cubic feet per minute, for each square inch of orifice. Now, suppose the opening under a forebay gate, required to pass the water of a stream, is 48 inches wide and 3 inches deep with a head of water (B) in forebay of 28 inches, then to find the water discharged, by Table, run down the columns marked "B" until you come to 28 inches, (head given in this example,) then run across to column F, and you will find 3.24 the number of cubic feet of water discharged by an orifice 1 inch square under 28 inches head. The area of the opening given, 48 inches by 3 inches, is 144 square inches; this multiplied by 3.24 gives 466.56 cubic feet that the above opening will discharge per minute. This table gives the actual and not theoretical discharge.

Spouting Velocity and Discharge of Water for Gate Orifices.

B	E	F	B	E	F	B	E	F	B	E	F
1	17.64	0.62	11	58.51	2.03	21	80.84	2.81	31	98.22	3.41
2	24.95	0.86	12	61.11	2.12	22	82.75	2.87	32	99.80	3.46
3	30.55	1.16	13	63.61	2.21	23	84.61	2.93	33	101.34	3.52
4	35.28	1.22	14	66.01	2.29	24	86.43	3.00	34	102.87	3.57
5	39.43	1.37	15	68.33	2.37	25	88.21	3.06	35	104.37	3.63
6	43.21	1.50	16	70.57	2.45	26	89.96	3.12	36	105.85	3.67
7	46.68	1.62	17	72.74	2.53	27	91.67	3.18	37	107.31	3.72
8	49.90	1.73	18	74.85	2.60	28	93.35	3.24	38	108.75	3.87
9	52.92	1.84	19	76.90	2.67	29	95.00	3.30	39	110.17	3.72
10	55.79	1.94	20	78.90	2.75	30	96.65	3.35	40	111.58	3.87

B. Head ni inches. E. Spoutnig velocity iu inches and decimals. F. Cubic feet discharged per minute for each square inch of orifice. Of course this method is not so accurate as the weir measurement.

but in many cases it answers the purpose quite as well. It should always be stated how many hours out of the whole day of twenty-four hours the stream will supply the gate measurement given. In writing us, send the width and the length of opening made by the gate when in use, and the depth of water in the forebay at the gate, that we may calculate for ourselves the quantity discharged.

Measurement of Water by Miner's Inches.

The definition of a miner's inch in different mining regions does not always agree. Usually, however, one square inch opening under a head or pressure of six inches above the opening, is taken as the standard of measure. For a small number of miner's inches the discharge per minute for each inch will be a trifle less than one and a half cubic feet, but for larger openings, where 50 to 100 or more inches are measured, the quantity will exceed one and a half, and the estimate may be safely made at one and six-tenths cubic feet discharged per minute for each miner's inch. The legal miner's inch is measured under a little less head than that mentioned; but the method above is the one most generally employed.

Actual Discharge of Water as Compared with Bucket Openings.

A well constructed Turbine Wheel does not discharge a quantity of water equal to its full measurement of apertures; or, in other words, in order for a well constructed Turbine to discharge a quantity of water equal to that which would flow through an orifice of a certain size under a given fall, and where the discharge is free and unobstructed, the apertures in the wheel must greatly exceed that of the simple orifice. The quantity of water discharged by different Turbines varies according to the construction. The controlling cause of this difference is the varying forms —curves and angles—given to the guides and buckets. The actual discharge of the Leffel Wheel is six-tenths of the combined area of its apertures. Suppose we take a wheel in which the total area of the apertures between its buckets amounts to 100 square inches; now, this wheel will not discharge a quantity of water equal to 100 square inches, but only equal to 60 square inches. It must be evident to every one that this difference results from the water being retarded in its flow through the guides by coming in contact with the wheel within the casing. To make this clear, even to those who are not fully versed in hydraulics, let us suppose, a wheel, the apertures of whose buckets measure 100 square inches, and place it under any given fall.

Now, let us suppose we remove the wheel from out the casing, and open the guides; the water will then flow freely and unobstructed through the guides into the empty space within the casing; as there is nothing to retard its flow, it will rush through the guides with a velocity due to the head under which it is placed. Now, by placing the wheel again within the casing, it acts as a clog or

check to the flow of water, as the water comes in contact with the buckets of the wheel, and instead of passing through the guides with the same velocity as before, it is held back, so that it now passes through the guides with only six-tents of its former velocity. Consequently, in order that a Turbine should discharge a certain quantity of water, the area of the apertures must greatly exceed that of the aperture that would discharge the same quantity under the same head, when allowed to flow into open air and freely retarded. The only reliable means of ascertaining the quantity of water that a Turbine of any established proportions will discharge, is by actual measurement of the water after passing through the wheel. The tables we publish of the quantity of water used by the James Leffel Wheel, are not the result of a mere measurement of their apertures and a consequent computation by theory, but are the results of numerous and repeated experiments and actual measurements of water after passing from the wheel; and the quantities, as laid down in our tables, will be found on trial not to vary in any material amount from the quantity stated, if the quantity is correctly measured.

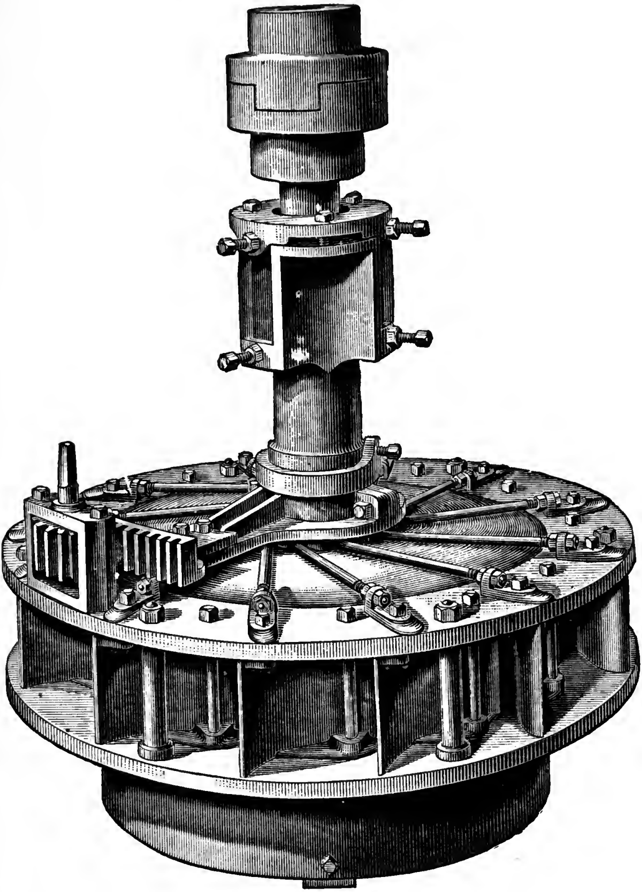
James Leffel's Improved Double Turbine Water Wheel.

An invention of but little real utility, may obtain, through lavish advertising and shrewd management, a temporary reputation, and for a short time meet with some sale among that class of persons who are continually on the lookout for novelty in everything. But time and varying conditions prove the worth of every machine, and the maintenance of a good reputation throughout a long period of years, must be regarded as an evidence of intrinsic merit.

THE JAMES LEFFEL DOUBLE TURBINE WATER WHEEL stands before the public as a thoroughly tested hydraulic motor to purchase which the buyer indulges in no doubtful experiment, the original design of the Leffel Wheel having been proven by the most exacting practical tests to be such as secures the greatest economy of water, together with the greatest degree of durability, ease of management and useful effect. It has been the aim of the manufacturers to improve minor working parts of the wheel, through greater accuracy in their formation, and increased durability of material. Years of diligent study and practical experience have enabled us to effect these most desirable improvements, which are now found in every wheel sent out from our works.

It is a common habit of the incompetent to copy from others that which they are unable to originate themselves. Hence it is that many manufacturers of inferior wheels—inferior both in principles of action and methods of construction, are not content with covert imitation, and, in many instances, with outright infringement of the Leffel Wheel, but they have appropriated the tabulated forms originated by James Leffel, modifying them in some instances by raising the figures repre-

JAMES LEFFEL'S



IMPROVED DOUBLE TURBINE WATER WHEEL.

senting amount of power furnished, in order to show an apparent increase of power over the Leffel Wheel, when it is to the Leffel Wheel alone the tables, as originally arranged, are applicable.

With a view of getting a testimonial for advertising purposes, rival wheel makers have sometimes resorted to the artifice of a private test in some obscure locality, with an old style worn out Leffel wheel and thoroughly prejudiced witnesses chosen by themselves, all without our knowledge or consent. Of course such tests can only result one way, the reported defeat of the Leffel Wheel, which is heralded abroad with a great flourish, and which forms the basis of flaming head-lines in the circulars and phamphlets of the parties in whose interest the so-called "test" was concocted and conducted. The exposure of such fraudulent tests is eventually more damaging to such parties than the groundless reports of defeat can possibly be to the Leffel Wheel.

How the Wheel has been Brought to Perfection.

No machine, however simple, durable and perfect in appearance, will in every respect prove satisfactory when first put into operation. Many parts will require, perhaps, a change of form, strengthening, or may be an entirely different arrangement, upon application to the work to be performed, after a trial of three or four years. In fact, it requires years of dilligent study and practical experience, particularly with a water wheel, to so perfect all of its parts as to make it successful under all circumstances, even though it be sound and practical in principle. Of course, many of the various kinds of wheels now offered for sale never can, by any amount of labor or attempted improvement, be made to operate all species of machinery, and must always remain but little better than worthless. To the general principle first stated the Leffel Double Turbine has perhaps been no exception. During its introduction for the first four or five years many of them were, no doubt, imperfectly made.

Amid the unparalleled growth of mechanical science, and the increasing knowledge of the principles and action of hydraulic motors, the makers of the Leffel Wheel have not been unmindful of such activity. Not only have the various parts of the wheel been greatly improved in design and ease of adjustment, but facilities for perfected manufacture of the entire wheel have been increased from time to time. Notably has this occurred during the past few months, when new, extensive, and convenient works have been built by us. These we have fitted out with entirely new, expensive, and especially designed machinery, constructed for the sole purpose of imparting to the wheel the necessary accuracy in workmanship, and of reducing the cost of manufacture, so as to enable us to offer, as we have long desired to do, not only the best, but in deed and in fact, the cheapest reliable water wheel in the market.

Among the most noticeable modifications and additions made (some of which are patented,) are the improved link for operating the

gates; the process for lining the iron plates with brass or any anti-corrosive metal (applied only when specially ordered); the combination of the toothed segment with the gate-arm in such a manner that the segment can be removed when the teeth become worn, and a new one supplied; the spherical iron penstock; the use of steel gates or guides for some sizes instead of iron; and the improved method of casting solidly in one piece, both wheels, by means of which the edge of the diaphragm can be made much thinner, and yet stronger, assisting also to separate more perfectly the due proportion of water to each wheel. Half the buckets being made of good boiler iron, and the fillets retaining them improved, both in form and strength, it is impossible to break or tear out any of them; as a result of which, out of the last 5,000 wheels put in operation, not one has lost a single bucket. One set of buckets can easily be bolted or riveted to the wheel flange, if it were considered advisable. All such bolted buckets, on whatever kind of wheel they may be used, are, however, liable to frequent derangement by working loose and striking the inside of casing and end of guides, often dropping entirely loose and breaking others; subjecting the parties to the expense and inconvenience of taking the wheel from the casing to replace the broken ones. We prefer and recommend only those cast solidly into the Leffel Wheel, thus enabling them to withstand the shock of blocks, stones, and other rubbish to which they are so often subjected, and avoiding also the annoyance of removing the wheel from casing. Practically the wheel itself is perfect. In fact the durability of the entire wheel and casing is such, that the whole amount of repairs called for at the large shops of the firm, per annum, is covered by a sum so extremely small, in view of the fact that about 11,000 wheels are in operation, as to be scarcely worth estimate. The firm have within the last ten years so arranged and systematized the process of manufacture that if any part is accidentally broken, it can at once be duplicated, another being supplied by express on receipt of the necessary information. In short the Leffel Improved Double Turbine has kept pace, from its first introduction, with the advanced developments of mechanical science; and for any purpose for which the power of water is employed, it may be safely guaranteed as having no equal in utility, economy, and durability.

Double Wheels.

An idea exists to a considerable extent, that water wheels may be so constructed, with two or more sets of buckets, in such a manner that each set of buckets may form a separate wheel, and that the water may be received first by one set of buckets, or one wheel, and after passing from from the first, then to operate on a second arrangement of buckets, or wheels, and so on with as many sets or wheels as there may be, or until the last one is passed or operated upon; thus, in their opinion, obtaining much greater per-

centage of the power of water than is ordinarily utilized by the use of well-constructed wheels of other kinds. In fact, a much greater power is often claimed for them than can possibly exist in the quantity of water used.

Again, there is another class of wheels claiming to be double wheels, which are in reality and principle but single wheels; their builders believing by such representation that the reputation and popularity of the Leffel Wheel (so celebrated for its truly double character,) may thus directly benefit them. A single wheel, either a center or a vertical discharge wheel, is commonly used, with partition through the middle of the tier of buckets, thus only dividing the wheel, without in the least changing the action of the water on the buckets on either side of the partition and without any modification of the principle of construction.

The Leffel Double Turbine should not be confounded with either of these classes of wheels, as it is constructed and acts upon entirely and essentially different principles, which are peculiarly characteristic of it as a water wheel, and upon which its good name and reputation have, to a great extent, been established. There is in it a combination of two independent sets and kinds of buckets, one a vertical, the other a central discharge, each entirely different in its principle of action upon the water, yet each wheel or series of buckets receiving its water from the same set of guides at the same time; but the water is acted upon but once, since half the water admitted by the guides passes to one wheel, and the other half of the water to the other wheel, being nicely separated and divided by the partition, or diaphragm between the two wheels, the water leaving both wheels or sets of buckets at the same time and as quickly as possible. These two sets of buckets are so combined as to make really but one wheel; that is, both are cast in one piece and placed upon the same shaft. By this arrangement there is admitted the greatest possible volume of water, to a wheel of any given size, consistent with its economical use, at both full and part gates, and at the same time the greatest area for the escape of water is secured. The surface in the wheel is thus reduced to minimum as compared with the quantity of water used, avoiding a very material loss by friction, which otherwise seriously diminishes the working power of a wheel. The value of this arrangement will be fully appreciated by those who understand the practical effect of the frictional surface in a water wheel. The cut on page 13 exhibits the general appearance of the wheel as completed and ready for attachment of shaft above it.

Infringements and Pretended Improvements.

We deem it necessary, from the many attempts being made to evade our patents, to call the especial attention of the public to that fact, so that no one may become innocently involved in

the trouble that must ensue by purchase of wheels and cases which are in part or wholly covered by several letters patent. It is well known that ALL GOOD AND SUCCESSFUL INVENTIONS ARE INFRINGED UPON; for as soon as the long and unwearied efforts of an inventor have been crowned with success, (despite the world of opposition he has to encounter,) and the merits and utility of his invention are established, there at once arises a host of imitators--those who have not the patience or genius of inventors, but who seek by some slight change or modification to appropriate to their own use the vital and essential points of a machine, hoping by a mere colorable change to escape their just liabilities to the inventor whose years of toil first gave to the world the invention they would fain wrest from him. This, the reader will at once see, is not invention—IT IS MERE PIRACY—and deserves to be spurned by all who recognize in a true inventor the greatest of all public benefactors.

The usual method employed to impose upon customers is, to offer some pretended improvement, which is done by taking some well known machine and attaching to it some part, which, however small, if it be new, is subject to a patent. For instance, a water wheel may have thirty to fifty of its parts and combinations protected by patents; yet any other part, however small, such as a bolt, nut arm, lever, pinion, strap, stirrup, gate, pivot, bridge-tree, bucket, bush, etc., if attached, and pronounced by the Patent officials a new and novel device, is patentable, whether an improvement or not; but such patent only covers the particular part in its connection with some other, and of course does not in the least grant any right or privilege to use any of the parts previously patented; such right to the use of other patented parts must be obtained through the full consent of, and from the parties holding such prior patents. But this is too often disregarded, and the rights of previous inventors totally ignored; this new inventor, presuming through ignorance, bigotry or dishonesty, that he is master of the entire situation, and however insignificant may be his little attachment or patent, is publishing and representing that he has discovered or invented an entirely new and improved water wheel; such falsification of the facts is the origin, sooner or later, of prosecutions against both the manufacturers and users of such infringements, and a source of almost endless litigation in the civil courts.

The Double Turbine Water Wheel and Case is the invention of James Leffel, to whom patents have been granted and re-issued from time to time, as improvements were added and applied; these patents having been granted not only in the United States, but also by Great Britain, France and Belgium. For a further protection to our customers and our trade, we now hold in whole and in part, both in fee simple and otherwise, a number of other well substantiated patents on water wheels and parts thereof.

As the extent of the liability arising from an infringing article is not generally understood by the public at large, we would here state that those who use or sell infringing articles are liable for damages as well as those who make them, hence, great caution should be exercised in purchasing; and as a rule those are safest to purchase that have been longest before the public and most extensively used.

The Leffel Water Wheel Patents Declared Valid.

We published heretofore the decision and decree of the United States Circuit Court for the Southern District of Ohio, in the suit in which the firm of James Leffel & Co. were plaintiffs, and the manufacturers of the so-called Thomas Leffel Wheel, defendants—the suit being brought to restrain the defendants from infringing the patents of James Leffel by the manufacture of the said Thomas Leffel Wheel. The decision of the Court fully and completely sustained the Leffel patents in every particular, absolutely confirming their validity; and a decree was rendered granting an injunction forbidding the manufacture of the defendants' wheel.

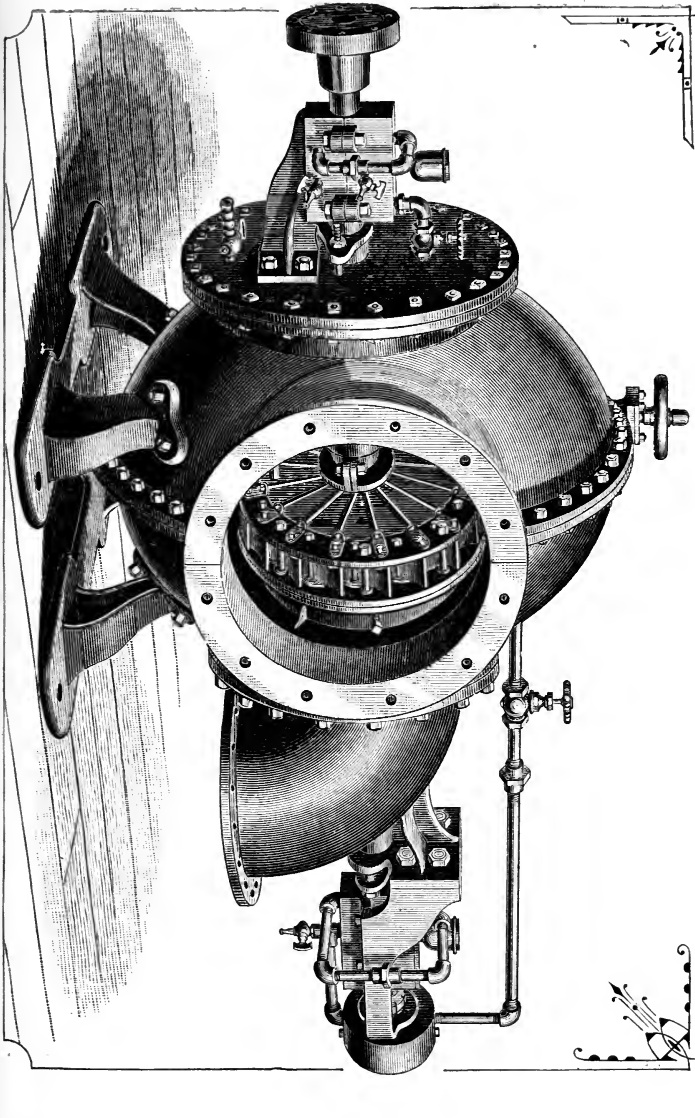
The defendants in this suit having, in pursuance of law, filed a motion for a re-hearing of the case, it again came up the last week in November, 1874, in the United States Circuit Court at Cincinnati; and after a thorough and exhaustive hearing, occupying nearly a week, in which the points at issue were argued at great length by the most eminent and able counsel, the Court, on Wednesday, the 2d of December, re-affirmed its former decision without reserve, exception, or modification. This decision, to which the Court has a second time given its authority, embraces in its scope all the valuable features of the Leffel Water Wheel, of the casing as relates to its portability, etc., and of the guides, recognizing and pronouncing James Leffel as their inventor.

It may be well, also, to remind those who intend purchasing water wheels, that the James Leffel Wheels are therefore not liable to damages, delays, and other annoyances that may arise from the use of many of the late patented and pretended "improved" wheels now on the market, which no doubt in many cases grossly infringe prior patents.

New Improved Vertical Mining Wheel.

On the following page (19) we illustrate a method comparatively new, in the application of Turbines to mining purposes. We have, however for the past eleven years, located wheels in horizontal positions, in each instance making and providing an arrangement somewhat to suit the circumstances; sometimes adapting our Patent Globe Case, and at other times the cylindrical, as seemed most convenient to suit the purpose.

The illustration, however, gives a view of our new design and pat-



ented casing, intended to be a more convenient modification of our patent globe case, which we have used for a number of years. The object attained in this new arrangement is economy of space, and the application of an extremely small inlet and headpipe; this latter being accomplished by a peculiar and patented arrangement in the upper or interior part of the casing. The new design effects also a great saving of power, by means of the use of anti-friction bearings which can be oiled; the whole being accessible and subject at any time to examination. The design is intended particularly for mining purposes; and for small wheels under high heads, where the use of gears is not only difficult of arrangement, and of keeping in order, but frequently impracticable otherwise.

The horizontal shaft of the water wheel on which is placed a pulley, aftords not only the simplest, but the most efficient means of connecting the power to the point where it is desired to be used. This is easily effected and any amount of power transmitted and motion obtained that may be desired, by properly proportioned pulleys with light but sufficient belting. The method, however, is not only applicable to mining purposes, but frequently may be attached to saw mills and other machinery where a simple and efficient arrangement is desired.

Important improvements have been made in this wheel within the past three years. These relate to the gate arrangement; obtaining greater regularity in closing and opening them; this being necessary under extremely high heads. Provision has also been made for keeping the journals cool under their very high speed, as they are not in the water or inside the casing, but on the outside. They are lubricated with oil, but are now provided with a water jacket. Avery effectual device is also now applied for relieving the step of the great presure that wheels are subject too when placed on horizontalsh afts. It is extremely simple and thoroughly efficient. A patent will shortly be issued for this devise, thus protecting us in its exclusive use.

At present we are making the wheels on this method for the sizes up to our 23 inch inclusive, and possably may adopt the same plan for still larger sizes where the peculiarity of the situation will render the application of this method the most practical. Of course, in the wheel proper we retain the essential principles of the Improved James Leffel Double Turbine Wheel. Having applied it to heads as high as 300 feet, we are confident in its ability to accomplish all that we promise, and to give entire satisfaction under any circumstances where a turbine can be used.

We cannot speak in too high praise of this arrangement for mining, pumping, and other purposes, and where it is desired to have the greatest power in the least possible space, having the smallest conducting pipe that can be used, and the simplest communication of the power to the work. We shall be pleased at any time to give full and further information, and to give prices for constructing the wheel and casing on this method. It will be necessary for us to learn in all

cases, however, the amount of head and pressure that can be obtained, the quantity of water that the streams afford by miner's measure, or otherwise, as we direct for such measurements in other parts of the pamphlet, and the amount and kind of machinery to be driven, as well as the work expected to be done.

To those About to Select a Water Wheel.

Do not purchase a common water wheel because from its low price it may seem to be cheap.

It costs as much money to erect an inferior wheel as it does to put up one of the most superior quality.

It is frequently found necessary to discard an inferior water wheel, and substitute one of better quality. This generally requires a change of gearing and other alterations, involving a large expense which might have been avoided by choosing the best wheel at first.

The best wheel is that which develops the most power from a given quantity of water, and which is the most manageable and durable under use.

The application of the best wheel adds greatly to the value of the water right.

The best is the cheapest, because it does more work, lasts longer, and costs no more to erect than a common wheel.

The Leffel Improved Double Tu bine Water Wheel is the best, and consequently the cheapest.

While it has been our aim to keep the Leffel Wheel up to the very highest standard of efficiency and economy, it has been no less our desire to so improve the process of manufacture that it could be brought within the means of the humblest manufacturer, giving thereby to a machine possessing the highest mechanical merit, the merit also of VERY REASONABLE COST.

It shall be our care, as in the past, to use the very best quality of material—in fact, we are constantly improving the same, as we now use for some of the parts of first sizes up to the 35 inch, a fine quality of steel, where before only iron was used.

Mining Wheel in Silver Reduction Works.

GEORGETOWN, COLO., February 1st, 1881.

Messrs. James Leffel & Co., Springfield, Ohio:

The "Vertical Turbine" made for our works proved a perfect success, accomplishing all promised for it. During the low stage of water it ran our mill night and day for five months, giving us probably 80 horse power with a head of 110 feet.

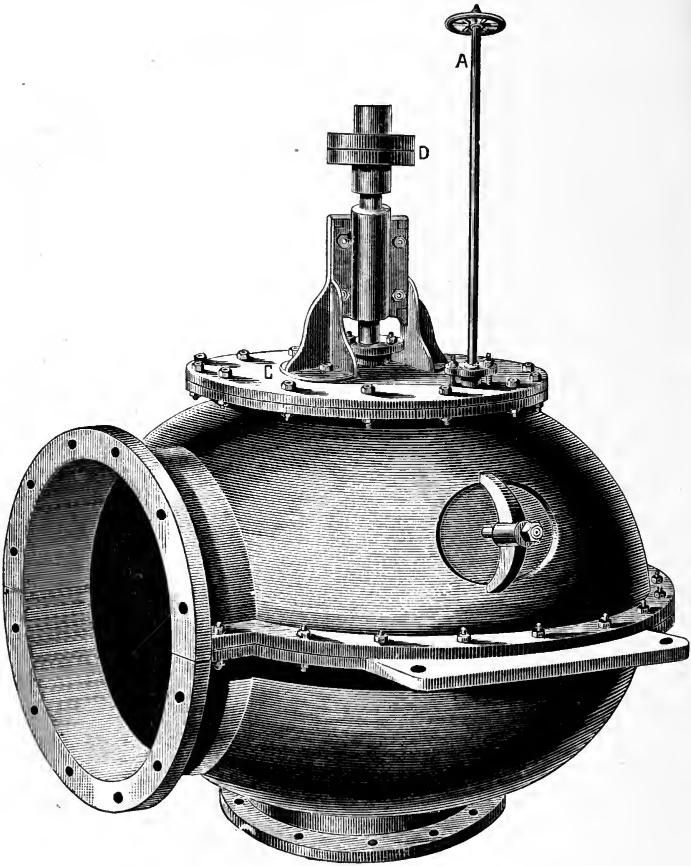
We consider it an economical and satisfactory investment.

Our machinery consists of Ore Crusher and Rollers, Sample Crusher, Three Batteries of Five Stamps each, Five Roasting Cylinders, Four Amalgamating Pans, Two Settlers, Circular Saw, Elevator, Screens, &c.

Very truly yours,

S. J. LEARNED, Manager.
Farwell (Silver) Reduction Works

JAMES LEFFEL'S



Improved Patent Globe Casing.

Leffel's Improved Patent Globe Casing.

The plate on page 22 represents our New and Improved Patent Globe cast Iron Penstock, or Casing, which we are now making, and in which many of our wheels are now placed. The form being that of a Globe or Sphere, it at once secures the greatest strength, with the least weight, and at the same time affords the largest space for the water to circulate above and around the wheel; while it also admits of the smallest exterior dimensions, and therefore occupies less space, than any other form or shape that can be adopted. As none of the parts are su bject to wear or breakage, it never requires replacing, and of course its durability is beyond question.

This casing is made in two hemispheres bolted together, thus enabling it to be easily taken apart, if at any time it should become necessary. There is a moveable cap or cover, C, bolted on the top of the casing, which can at any time be removed, (when the head of water is not standing in the case,) and the wheel lifted bodily out of the casing, the opening in top of same being amply large for that purpose, though it is seldom necessary to remove the wheel from any cause. There is one large man-hole on the side, also a hand-hole, B, on the top cover, through which any obstruction can be removed, that may by carelessness or accident get into the casing; through these holes the wheel can at any time be examined. On the top of cap, C, is bolted firmly a bridge-tree, carrying a good, broad oil bearing, for the support of the upper end of the water wheel shaft, to which a clutch coupling, D, is attached, immediately above said bridge-tree. In the cover or cap, C, are arranged neat, snug and tight stuffing-boxes, through which the gate rod A and water wheel shafts pass, and by which any water is prevented from discharging; they are supplied with tightening bolts by which they can be tightened down should the packing at any time become worn or loose; they admit also of the packing box being entirely taken out and the stuffing renewed at any time. In fact, the whole affair, when well set and arranged, is perfectly watertight, not leaking a drop, and could be located upon a floor near to any of the machinery if desired.

They cannot be frozen up, since the iron is thick, and the circulation of water always sufficient to prevent freezing. A short tube or cylinder is attached to the bottom, which is intended to be slightly submerged under the standing tail-water; it has a flange with its face turned and with bolt holes, as the illustration shows, to which an iron tube can be attached, and by a little care a perfectly air tight joint can be made; the tube may be any length, provided the perpendicular height from wheel to tailwater does not exceed 28 to 30 feet; in all cases, however, where the draft tube becomes necessary, make it as short as possible. In cases where such draft tube is used, of course the entire casing can be set higher, and sometimes in a more convenient location.

The methods usually employed in setting this combined wheel and

Globe Case are illustrated in several pages further along in this pamphlet. The one to be preferred, however, is that shown in cut of Circular Saw Mill, where the quarter turn belt is used. A good substantial foundation of stone is built, upon which timbers are bolted or permantly laid, and to these timbers the horizontal flanges or lugs at the sides and center of globe are fastened. These foundation lugs are almost exclusively made now as shown in that cut, projecting from the central part, as the engraving on the foregoing page (22) represents. By placing them centrally and on the sides, the wheel and globe can be more conveniently set, and much more solidly located.

It is of course understood that our Wheel and its case are constructed in the ordinary manner, with the exception that the shaft is made longer, in order to adapt it to the Globe. They are then placed inside of this flume or outward casing, as it may be termed. To the Globe Casing may be attached any length and shape of piping desired; several of the following illustrations represent such attachments. Often it is unnecessary to connect any piping to it, as the location of wood flume is such as to admit of bolting the inlet flange directly to the planking as some of the cuts illustrate; but we would prefer in almost all cases to use a short, straight tube of four to ten feet, thus placing the casing in a dryer location, since all the wooden flumes are more or less subject, after a few years, to leakage, and all objects near liable to dampness.

We cannot say too much in praise of this Casing, particularly for high falls; being made strong and watertight, it will always remain so. It has been fully tried and tested under almost every circumstance, and has proven in the highest degree satisfactory; some of them are under heads from 80 to 260 feet and stand the tremendous pressure admirably. In fact, almost all of our small Wheels up to 20 inches diameter are now ordered by our customers to be encased in this manner, such has been the satisfaction they have given. Of course it is not absolutely necessary to use it, except in particular instances, where a want of space or other circumstances would prevent the erection or use of a wood flume or box in which to place the wheel; but any time and under almost any condition it is preferable and makes a number one arrangement, especially in any case whatsoever where the power is taken off below headwater. But its greatest convenience is locating wheels under mills, and in other difficult places, where posts, foundations, walls, etc., can not be removed; such difficulties being obviated by the compactness of its form, and the ease with which it can be connected to the headwater by a pipe of suitable size.

Six Large Wheels in his Saw and Shingle Mills.

MERRILL, WISCONSIN January 9th, 1883.

Messrs. James Leffel & Co., Springfield, Ohio.

GENTS.—I am using six of your wheels, size from 48 inch to 72 inch, and they perform all that they are recommended to do, and I regard them as the best wheel in use in this locality. They give me perfect satisfaction. Yours truly,

THOMAS B. SCOTT.

Wheels Running 18 Years—20 Barrels Flour per Hour.

THREE RIVERS, MICH., April 1, 1885.

James Leffel & Co., Springfield, Ohio:

DEAR SIRS—I am using three of your old style Water Wheels to run my flouring mill, which is a full roller mill with complete set of machinery, and make on an average 20 barrels per hour but have made more. The working head of water under favorable circumstances is 12 feet, and use two 48 wheels of 12 buckets to drive the rolls, and one 48 wheel with 16 buckets for driving machinery. The wheels that drive the rolls are generally used full gate, the machinery wheel generally about ¾ gate. The wheels are giving good satisfaction, run every day, and have not needed repairing since they were re-set over two years ago. Two of the wheels have been in constant use about 18 years, and I think run just as well as when new.

Yours truly, W. G. CALDWELL, Supt.,
For L. EMERY, Jr.

Mining Wheels Under 182 and 100 Ft. Heads.

DAHLONEGA, GA., April 1st, 1885.

Messrs. James Leffel & Co., Springfield, Ohio:

GENTLEMEN—In reply to your favor of 25th inst touching the performance of your Leffel Wheel in this section, I will say, I have, as you know sold a number of your wheels, and never in the first instance have I heard a complaint. One wheel (13¼ inch mining special pattern) running under 182 ft. head, driving 60 stamps with about ⅝ gate and gives equally good results with partial or less gate driving a less number of stamps. Another wheel, same size under 100 ft. head driving 20 stamps with half gate and parties say no more trouble than a low pressure wheel near here. Two wheels 23 inch driving grist mill under 12 ft. head, 12 or 15 bushels of corn per hour, with half gate and doing fair work under only 6 ft. head at times, which gives entire satisfaction. One 44 and one 56 under about 18 ft. head, doing heavy duty at the "Garnet" mine driving pump and stamps, and parties say working fully up to the guarantee and gives entire satisfaction. I can hear no other expression from the use of your wheels, than as above stated and I will add, as a millwright and mechanic, that I believe them to be the best wheel in the market, and cannot fail to give satisfaction in every instance where properly erected.

With respect I am Yours truly.

FRANK W. HALL.

Using Six, Never give any Trouble.

CEDAR FALLS, IOWA, April 4th, 1884.

James Leffel & Co.:

I am highly pleased with your Water Wheels, which have never given me trouble. I am using six of your make and two of others, a Jonval and a Houston; the latter are fine wheels but bad gateage. I use a thirty special Leffel to drive my Midly's stone; a forty eight special to drive machinery in flour mill; a forty to drive just six breaks (Roller Mills); a forty eight to drive 8 pairs smoth Roller Mills, a forty and a forty eight to drive fuel mill, all under an eight to ten foot head.

I am respectfully yours, G. N. MINER.

Driving 18 Pairs Rollers.

GRAFTON, WIS., March 30th, 1885.

James Leffel & Co.:

GENTLEMEN—The 44 inch, special size of Water Wheel we bought of you works excellent; it is running under 13—14 feet head with ¾ of gate; it drives the whole mill, containing 18 pair of rollers; one 3½ foot middling stone; one 4¼ foot feed stone; one brush machine; one scourer; one separator; four dust collectors five centrifugal reels; one bran duster; four purifiers; nine scalping reels; two flour packers; 37 elevators; two 4 reel Rolling chest. We had a 26½ inch wheel in our old mill, which we have sold now for $100, which was in use every working day since 1870.

Yours truly,

H. SMITH & CO.

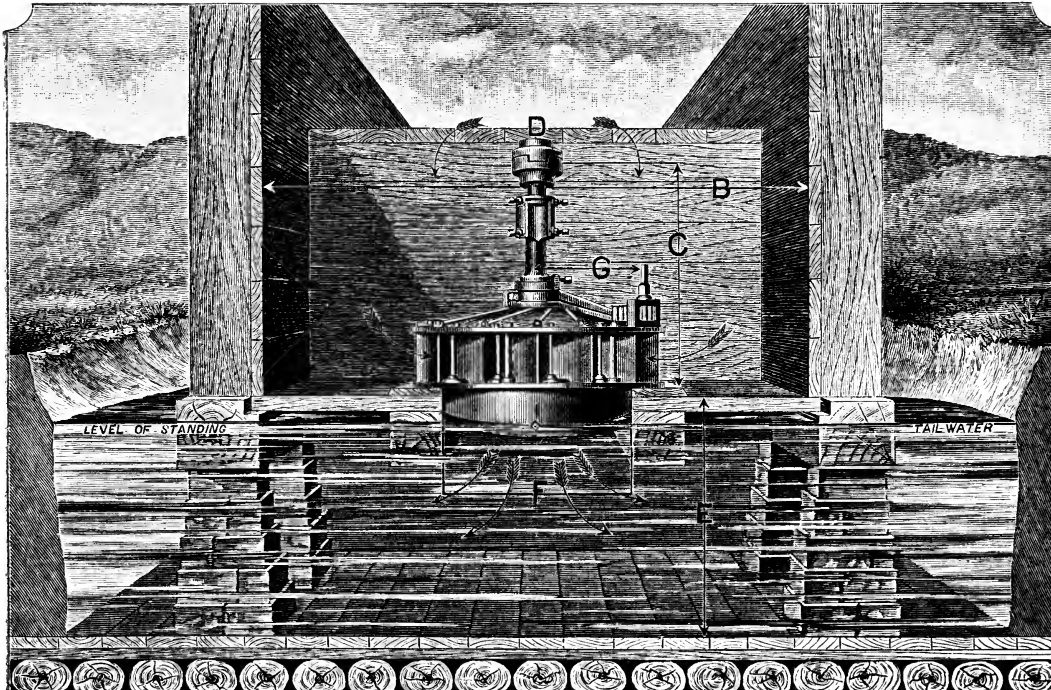

D
B
C
G
LEVEL OF STANDING
TAIL WATER
F
E

Table of Dimensions of James Leffel's Improved Turbine Water Wheels.

[THE LETTERED COLUMNS IN TABLE CORRESPOND WITH THE DOTTED LINES IN CUT ON OPPOSITE PAGE.]

		B	C*	D	E	F	G	
SIZE OF WHEEL.	Diameter of Entire Casting.	Internal Diameter of Flume.	Length of Shaft from Flange on Floor of Flume to Center of Coupling.	Diameter of Bore in upper half of Coupling.	Depth of Pit from Floor where wheel rests to bottom of Pit.	Diameter of hole in the bottom of Flume for Wheel Cylinder.	Distance from center of Gate rod to center of Wheel Shaft.	Cross Section of Entrance for water to Penstock.
10	14½	30 to 38	16¼	1⅛	30 to 33	13	6½	24 by 38
11½	16½	32 to 40	17¼	1⅛	30 to 33	14	7¼	26 by 40
13¼	19¼	34 to 43	18¼	1⅜	32 to 35	17	8½	28 by 43
15¼	22	38 to 46	21¾	1⅞	32 to 35	18	10½	30 by 40
17½	24¾	42 to 50	24	2	35 to 40	21	11¾	33 by 50
20	28	46 to 54	27¼	2⅛	35 to 40	23¼	13¼	35 by 54
23	33	50 to 59	34¼	2⅝	38 to 43	27	15¼	38 by 59
26½	38¼	54 to 65	37⅛	2⅞	40 to 45	31½	16¾	42 by 65
30½	43½	65 to 72	38½	3⅛	42 to 48	35	19¼	46 by 72
35	50	72 to 79	44⅜	4⅜	44 to 50	40	22½	50 by 79
40	56½	79 to 90	46¼	4⅜	48 to 54	45	25½	54 by 90
44	60	90 to 99	50½	4⅜	50 to 56	50	27½	56 by 99
48	67	99 to 108	57¼	5⅜	55 to 60	53	30½	60 by 108
56	80½	118 to 128	68	5⅞	60 to 68	62	36	66 by 128
61	85	128 to 140	68	5⅞	62 to 70	67	37½	68 by 140
66	89	137 to 152	70	5⅞	64 to 74	72	40½	70 by 152
74	102½	150 to 166	75	6	68 to 80	80	46	71 by 166
87	112½	165 to 183	82	6½	72 to 90	95	52¼	72 by 183

NOTICE.—All the measurements in the above Table are made in inches, and fractions of Inches.

*The measurements in this column (C) are close, but not absolutely correct in all cases.

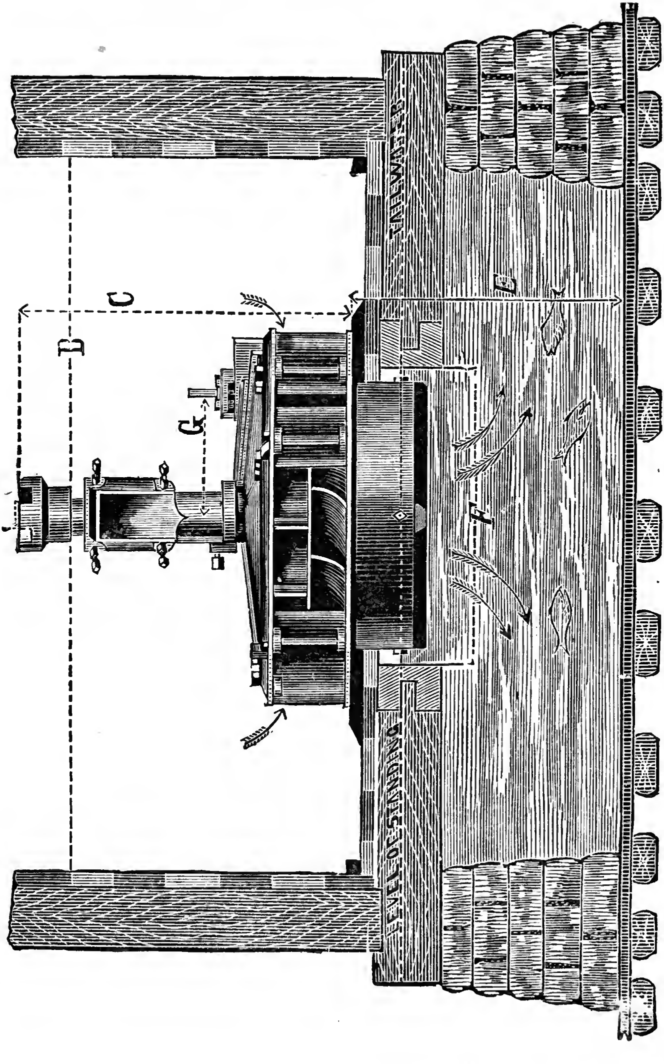

TAIL WATER
LEVEL OF STANDING

Table of Dimensions of James Leffel's Improved Special Turbine Water Wheels.

[The Lettered Columns in Table Correspond with the Dotted Lines in Cut on Opposite Page.]

SIZE OF WHEELS.	Diameter of Wheel and Casing.	B Internal Dimensions of Penstock.	C* Hight of Shaft from floor of Penstock to center of Coupling.	D Diameter of bore in upper half of Coupling.	E Depth of Pit from floor where wheel rests to bottom of Pit.	F Diameter of hole in the floor of Flume for wheel Cylinder.	G Distance from center of gate rod to center of wheel shaft.	Cross Section or size of entrance for water to Penstock.	WEIGHT OF WHEELS.
No. 2	114	167 to 185	85	6½	74 to 92	95	52	74 by 185	
No. 3	103½	152 to 168	78	6	70 to 82	80	46	71 by 168	
No. 4	90½	140 to 154	73	5⅞	64 to 76	72	40½	69 by 154	
No. 5	86	130 to 143	61½	5⅞	62 to 72	67	37½	67 by 143	
No. 6	81½	128 to 130	61	5⅞	60 to 70	62	36	65 by 130	
No. 7	68½	105 to 115	63	5⅜	56 to 64	55½	32½	61 by 117	
No. 8	62	92 to 102	54	4⅜	52 to 58	49	27½	58 by 102	
No. 9	58½	82 to 93	49½	4⅜	50 to 56	45	25½	56 by 93	
No. 10	51½	74 to 81	47½	4⅜	46 to 52	40	22½	52 by 81	
No. 11	45	66 to 74	40½	3⅛	44 to 50	35	19¼	48 by 74	
No. 12	40	55 to 66	39½	2⅞	42 to 46	31½	16¾	44 by 66	
No. 13	34½	52 to 60	36½	2⅝	40 to 44	27	15¼	40 by 60	

Table of Dimensions of Leffel's Patent Globe Cases for Wheels up to Forty-eight Inches.

[THE LETTERED COLUMNS IN TABLE CORRESPOND WITH THE DOTTED LINES IN CUT ON OPPOSITE PAGE.]

	A	B	C	D	E	M	H	I	K	L	N	Shaft.	Price.
SIZE OF WHEEL.	Dist. from face of flange of inlet to center of Wheel Shaft.	Diam'r of Bore of Inlet Pipe.	Distance across flanges of Inlet.	Diam'r of Bore of Outlet Pipe or Cylinder.	Distance across flanges of Cylinder or Outlet Pipe.	Diam'r of Globe between foundation sills.	Dis. from foundation where wheel rests to top of Shaft,	Dis. from center of Flume to top of Shaft.	Length from top of Flume to top of Shaft.	Dis. betw'n centers of Wheel Shaft and Gate-Rod.	Dis. from foundation sills to end of Outlet Pipe.	Bore of upper half of Couple.	Including fitting of wheel into flume.
6⅝	16	11½	15¾	8¾	13	29	27	25½	10¾	4⅜	10½	1	$ 75
7⅝	16	11½	15¾	8¾	13	29	27	25½	10¾	5⅛	11	1	$ 78
8¾	17	14½	20½	11	16	31½	33	31½	13½	5⅝	11½	1⅛	$ 81
10	17	14½	20½	11	16	31½	33	31½	13½	6½	11⅞	1⅛	$ 85
11½	20	18½	24	13¾	20	37½	35	33½	16½	7¼	13½	1⅛	$ 90
13¼	20	18½	24	15	20	37½	35	33½	16½	8½	14¾	1⅜	$100
15¼	21	21½	26½	17	23	42	37½	36	17	10½	16	1⅞	$115
17½	24	23½	30	20	25½	50	40	38½	17½	11¾	16	2	$130
20	26	26½	32½	22¾	28¼	53½	42	40½	19	13¼	17¾	2⅛	$150
23	28	31	37¾	25	30½	60	45	43½	20	15¼	19¾	2⅝	$175
26½	30	35	40½	28	33*	65*	63*	47½*	21	16¾	*	2⅞*	$205
30½	34½	40	45½	32¾	39*	72*	68*	*	22	19¼	*	3⅛*	*
35	40	48	54	38½	45¼*	96*	89*	*	28	22½	*	*	*
40	44½	54	60	44½	51*	96*	90*	*	29	25¾	*	*	*
44	49	58	64½	48½	58¼*	106*	96*	*	30	27½	*	*	*
48	53¾	64	70	52¾	64¼*	114*	100*	*	30	30½	*		*

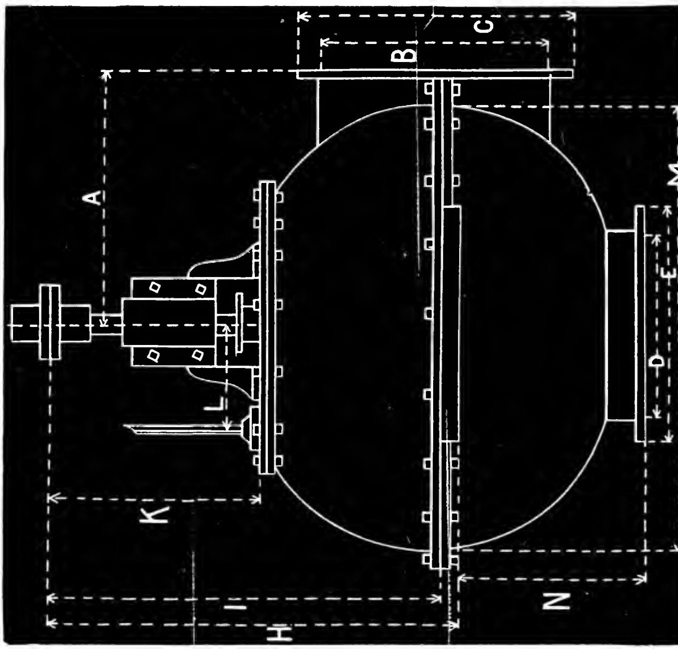
The Capital Letters at heads of columns refer to corresponding Letters in the cut on opposite page. For cases larger than 48 inch wheels, we make special contracts, the price being governed by the location and head.

* These cases are made with flat top and bottom and vertical sides of boiler iron. They are not suspended at side or center as the Globes, but the foundation is directly underneath. All the above measurements are made by INCHES.

NOTE.—The measurements, H. I. K. N., are not absolutely correct, since they vary to some extent in the manufacture of each Globe, and can only be relied upon in a general way, or as approximations.

OUTLINE PLATE OF GLOBE SHOWING DIMENSIONS.

This plate is to be examined in connection with the table on foregoing page, in order that each dimension may be easily recognized and understood. Like lettering in each indicates the proper numbers or dimensions. A mere examination and comparison of both will render further explanation on that point unnecessary.



OUTLINE PLATE OF GLOBE PENSTOCK.

One Wheel Driving Eight Run of Stone, Etc.

SYRACUSE, NEW YORK, February 5, 1881.

Messrs. James Leffel & Co., Springfield, Ohio :

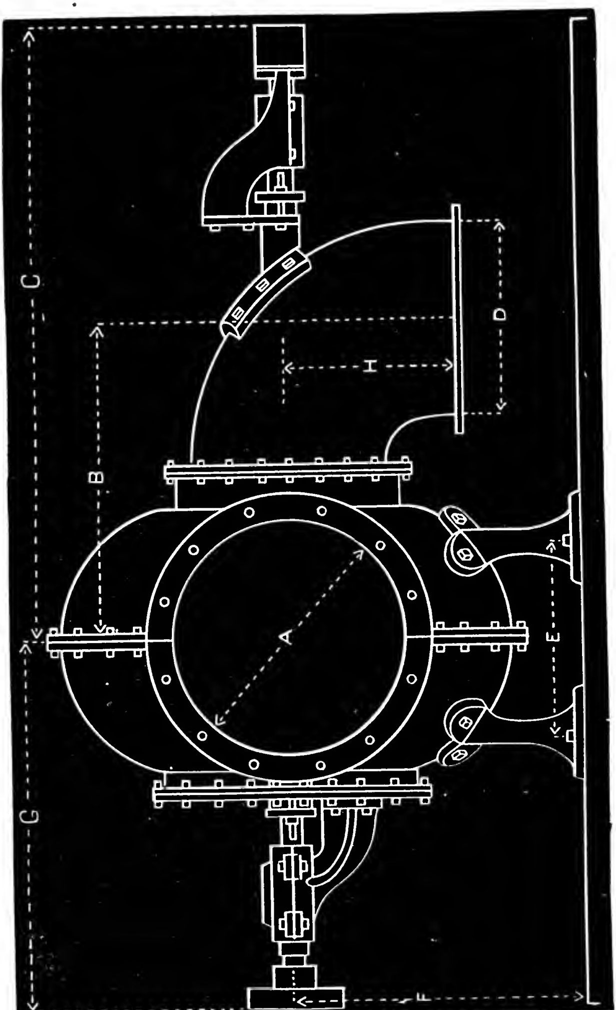
GENTS—It is now about two years since we have been running your 40 inch wheel, and we must say that it gives entire satisfaction. We are very much pleased with it. It does all the work you claimed it would do, and a little more. We have a 26 foot fall and run eight run of four and one-half foot stone, two set of rolls, and all the necessary elevators, bolts, etc. JACOB AMOS & SONS.

Table of Dimensions of James Leffel's Improved Mining Turbine Water Wheels.

[THE LETTERED COLUMNS IN TABLE CORRESPOND WITH THE DOTTED LINES IN CUT ON OPPOSITE PAGE.]

Mining Wheels.	A	B	C	D	E	F	G	H			
SIZE of WHEELS	Bore of inlet opening.	Dis. from center of casing to center of draft tube.	Dis. from center of casing to end of step or shaft.	Bore of outlet or draft tube.	Dis. between centers of feet of foundation.	Dis from foundation level to center of wheel shaft.	Horizon. dis. from center of case to center of couple on wheel shaft.	Dis. from wheel shaft to end of discharge pipe.	Dis. from face of flange of inlet opening to center of wheel shaft.	PRICE.	
10 No. 2.	14½	25	46½	11	19	19	31½	12½	17	$375	
10 No. 1.	14½	25	46½	11	19	19	31½	12½	17	375	
10	14¼	25	46½	11	19	19	31½	12½	17	375	
11½	14¼	25	46½	13½	19	19	31½	12½	17	375	
13 No. 1.	18½	25¾	54	15	25	23½	36	10½	20	430	
13¼	18½	25¾	54	15	25	23½	36	10½	20	430	
15¼	18½	36	64	18	25	23½	36	10½	20	430	
17½	21½	34	66	20	22¼	23	38	19½	21	500	
20	23½	40	72	22¾	21	27	39	22	24	500	
23	26½	42	78	22¾	22½	28½	41	23	26½	575	

NOTICE—All the measurements in the above Table are made in Inches, and fractions of Inches.



Outline Plate of Leffel's Mining Wheel.

Table Specially Arranged, Expressly for James Leffel's Improved Double Turbine.

HEAD.	SIZE OF WHEELS.	6⅝	7⅝	8¾	10	11½	13¼	15¼	17½	20	23	26½
3	Horse Power...	.15	.20	.25	.33	.44	.58	.76	.97	1.3	1.7	2.2
	Cubic Feet......	29	39	49	67	87	116	151	197	260	347	451
	Revolutions....	360	313	273	239	207	180	157	136	119	104	90
4	Horse Power...	.22	.30	.38	.52	.67	.90	1.0	1.5	2.0	2.6	3.5
	Cubic Feet......	33	45	57	77	100	134	174	227	301	401	521
	Revolutions....	416	362	315	275	240	208	181	158	138	119	104
5	Horse Power...	.31	.42	.53	.72	.94	1.2	1.6	2.1	2.8	3.7	4.8
	Cubic Feet......	37	50	64	86	112	149	194	254	336	448	583
	Revolutions....	465	405	352	308	268	233	202	176	154	134	116
6	Horse Power...	.41	.56	.70	.95	1 2	1.6	2.1	2.8	3.7	4.9	6.4
	Cubic Feet......	41	55	70	94	123	164	213	278	368	491	638
	Revolutions....	510	444	386	337	293	255	221	193	169	147	127
7	Horse Power...	.52	.70	.88	1.1	1.5	2.0	2.7	3.5	4.6	6.2	8.1
	Cubic Feet......	44	60	75	102	133	177	230	301	398	531	690
	Revolutions....	551	478	417	364	317	275	239	208	182	159	138
8	Horse Power...	.63	.86	1.0	1.4	1.9	2.5	3.3	4.3	5.7	7.6	9.0
	Cubic Feet ...	47	64	80	109	144	189	246	321	425	567	737
	Revolutions....	588	511	446	390	339	294	256	223	195	169	147
9	Horse Power...	.76	1.0	1.2	1.7	2.2	3.0	3.9	5.1	6.8	9.0	11.8
	Cubic Feet......	50	68	85	115	150	201	261	341	451	602	782
	Revolutions....	624	542	473	414	359	312	271	236	207	180	156
10	Horse Power...	.89	1.2	1.5	2 0	2.6	3.5	4.6	6.0	7.9	10.6	13.8
	Cubic Feet.....	53	71	90	122	159	211	275	359	476	634	824
	Revolutions.....	658	572	498	436	379	329	286	249	218	190	164
11	Horse Power...	1.0	1.3	1.7	2.3	3.0	4.0	5.3	6.9	9.2	12.2	15.9
	Cubic Feet......	55	75	94	128	166	222	288	377	499	665	864
	Revolutions.....	690	600	523	457	397	345	300	261	229	199	173
12	Horse Power...	1.1	1.6	1.9	2.6	3.5	4.6	6.0	7.9	10.4	13.9	18.1
	Cubic Feet......	58	78	98	133	174	232	301	393	521	695	903
	Revolutions.....	721	626	546	473	415	360	313	273	239	208	180
13	Horse Power...	1.3	1.7	2.2	3.0	3.9	5.2	6.8	8.9	11.8	15.7	20.5
	Cubic Feet......	60	81	102	139	181	241	313	410	542	723	940
	Revolutions.....	750	652	568	497	432	375	226	284	249	217	188
14	Horse Power...	1.5	1.9	2.5	3.3	4.4	5.8	7.6	10.0	13.2	17.6	22.9
	Cubic Feet.....	63	84	106	144	188	250	325	425	563	750	975
	Revolutions.....	779	677	590	516	448	389	338	295	258	224	195
15	Horse Power...	1.6	2.2	2.7	3.7	4.8	6.5	8.4	11.0	14.6	19.5	25.4
	Cubic Feet.....	65	87	110	149	194	259	337	440	582	777	1009
	Revolutions.....	806	700	610	534	464	403	350	305	267	232	201
16	Horse Power...	1.7	2.4	3.0	4.1	5.3	7.1	9.3	12.2	16.1	21.5	28.0
	Cubic Feet......	67	90	114	154	201	267	348	455	602	802	1043
	Revolutions.....	832	723	630	551	479	416	362	315	276	240	208
17	Horse Power...	1.9	2.6	3.3	4.5	5.9	7.8	10.2	13.3	17.6	23.5	30.6
	Cubic Feet ...	69	93	117	159	207	276	358	469	620	827	1075
	Revolutions.....	869	745	650	568	494	429	373	325	284	242	214
18	Horse Power...	2.1	2.8	3.6	4.9	6.4	8.5	11.1	14.5	19.2	25.7	33.4
	Cubic Feet......	71	94	121	163	213	284	369	482	638	851	1106
	Revolutions.....	883	767	668	585	508	441	384	334	293	254	221
19	Horse Power...	2.3	3.1	3.9	5.3	6.9	9.2	12.0	15.7	20.9	27.8	36.2
	Cubic Feet......	73	98	124	168	219	291	379	495	656	874	1136
	Revolutions.....	907	788	687	601	522	454	394	343	300	261	227
20	Horse Power...	2.5	3.3	4.2	5.7	7.5	10.0	13.0	17.0	22.5	30.1	39.1
	Cubic Feet.....	75	101	127	172	224	299	489	508	673	897	1166
	Revolutions.....	931	809	704	617	536	465	405	352	308	268	233
21	Horse Power...	2.7	3.6	4.5	6.2	8.1	10.7	14.0	18.3	24.2	32.3	42.1
	Cubic Feet	77	103	130	176	230	306	398	521	689	919	1194
	Revolutions.....	954	828	722	632	549	477	414	361	316	275	238

See explanation page 45. Price list page 49.

Table Specially Arranged, Expressly for James Leffel's Improved Double Turbine.

HEAD.	SIZE OF WHEELS.	6⅝	7⅝	8¾	10	11½	13¼	15¼	17½	20	23	26½
22	Horse Power...	2.9	3.9	4.9	6.6	8.6	11.5	15.0	19.6	26.0	34.7	45.1
	Cubic Feet......	78	106	133	180	235	313	407	533	705	940	1223
	Revolutions.....	976	847	739	647	567	488	424	369	323	281	244
23	Horse Power...	3.1	4.1	5.2	7.1	9.2	12.0	16.0	21.0	27.8	37.1	48.2
	Cubic Feet......	80	108	136	184	241	321	417	545	721	962	1250
	Pevolutions.....	998	867	756	661	574	499	433	378	331	287	249
24	Horse Power...	3.3	4.4	5.6	7.5	9.8	13.1	17.1	22.4	29.6	39.5	51.4
	Cubic Feet......	82	111	139	188	246	327	426	557	737	982	1277
	Pevolutions.....	1019	886	772	675	587	510	443	386	338	294	255
25	Horse Power...	3.5	4.7	5.9	8.0	10.5	14.0	18.2	23.8	31.5	42.0	54.6
	Cubic Feet......	84	113	142	192	251	334	434	568	752	1003	1306
	Revolutions.....	1046	904	788	689	599	520	452	394	345	300	260
26	Horse Power...	3.7	5.0	6.3	8.5	11.1	14.8	19.3	25.2	33.4	44.6	57.9
	Cubic Feet	85	115	144	196	256	331	443	579	767	1022	1329
	Revolutions.....	1061	922	803	703	611	530	461	402	341	306	265
27	Horse Power...	3.9	5.3	6.6	9.0	11.8	15.7	20.4	26.7	35.4	47.2	61.3
	Cubic Feet......	87	117	148	200	260	347	451	590	781	1042	1354
	Revolutions.....	1081	939	819	716	622	540	470	409	358	311	270
28	Horse Power...	4.1	5.6	7.0	9.5	12.4	16.6	21.6	28.2	37.3	49.8	64.8
	Cubic Feet......	88	119	150	203	265	354	460	602	796	1061	1379
	Revolutions.....	1101	956	835	729	634	550	478	417	365	317	275
29	Horse Power...	4.3	5.9	7.4	10.0	13.1	17.5	22.7	29.7	39.4	52.5	68.3
	Cubic Feet......	90	121	153	207	270	360	467	612	810	1079	1404
	Revolutions.....	1120	973	848	744	645	560	487	424	371	323	280
30	Horse Power...	4.6	6.2	7.8	10.6	13.8	18.4	23.9	31.3	41.4	55.3	71.8
	Cubic Feet......	92	124	156	211	275	365	476	622	824	1098	1428
	Revolutions.....	1140	990	863	755	657	570	495	431	378	328	285
31	Horse Power...	4.8	6.5	8.2	11.1	14.5	19.3	25.1	32.9	43.5	58.0	75.5
	Cubic Feet......	93	126	158	214	279	372	484	633	837	1117	1451
	Revolutions.....	1158	1007	877	767	667	579	503	439	384	334	290
32	Horse Power...	5.0	6.8	8.6	11.6	15.2	20.3	26.4	34.5	45.6	60.9	79.1
	Cubic Feet......	95	128	161	217	284	378	492	643	851	1134	1475
	Revolutions.....	1177	1024	891	780	678	589	511	446	390	339	294
33	Horse Power...	5.3	7.1	9.0	12.2	15.9	21.2	27.6	36.1	47.8	63.7	82.9
	Cubic Feet......	96	130	163	221	288	384	499	653	864	1152	1497
	Revolutions.....	1195	1039	905	792	688	598	519	453	396	344	299
34	Horse Power...	5.5	7.5	9.4	12.7	16.6	22.2	28.9	37.8	50.0	66.7	86.7
	Cubic Feet......	97	132	166	224	292	390	507	663	877	1169	1520
	Revolutions.....	1213	1055	919	804	699	607	527	459	402	350	303
35	Horse Power...	5.8	7.8	9.8	13.3	17.4	23.2	30.2	39.5	52.2	69.7	90.6
	Cubic Feet.....	99	134	168	227	297	396	514	672	890	1186	1542
	Revolutions.....	1231	1070	932	816	709	616	535	466	408	355	308
36	Horse Power...	6.0	8.1	10.3	13.9	18.1	24.2	31.5	41.1	54.5	72.6	94.4
	Cubic Feet......	100	139	171	231	301	401	521	682	902	1203	1564
	Revolutions.....	1249	1085	945	837	719	624	542	473	414	360	312
37	Horse Power...	6.3	8.5	10.7	14.4	18.9	25.2	32.8	42.9	56.8	75.7	98.4
	Cubic Feet......	102	137	173	234	305	407	528	691	915	1220	1585
	Revolutions....	1266	1100	958	838	729	633	550	479	419	365	316
38	Horse Power..	6.5	8.8	11.1	15.1	19.7	26.2	34.1	44.6	59.1	78.8	102.4
	Cubic Feet......	103	139	175	237	308	412	536	700	927	1236	1607
	Revolutions.....	1283	1115	971	850	738	641	557	486	425	369	321
39	Horse Power...	6.8	9.2	11.6	15.7	20.4	27.3	35.5	46.4	61.4	81.9	106.5
	Cubic Feet......	104	141	177	240	313	417	543	710	939	1252	1628
	Revolutions.....	1299	1129	984	861	747	650	564	492	430	374	325
40	Horse Power...	7.0	9.5	12.0	16.3	21.2	28.3	36.8	48.2	63.8	85.1	110.6
	Cubic Feet......	106	143	180	243	317	428	550	719	951	1268	1648
	Revolutions.....	1316	1144	996	874	758	658	572	498	436	379	329

See explanation page 45. Price list page 49.

Table Specially Arranged, Expressly for James Leffel's Improved Double Turbine.

HEAD.	SIZE OF WHEELS.	30½	35	40	44	48	56	61	66	74	87
3	Horse Power..	3.0	3.9	5.2	5.9	7.5	13.1	15.1	18.1	22.0	29.0
	Cubic Feet.....	602	793	1042	1213	1506	2556	3010	3612	4419	5761
	Revolutions....	78	68	60	55	50	42	40	36	32	28
4	Horse Power..	4.6	6.1	8.0	9.4	11.6	19.7	23.3	28.0	34.3	44.7
	Cubic Feet.....	695	916	1203	1400	1738	2931	3416	4170	5106	6662
	Revolutions....	90	79	69	63	57	49	45	40	37	33
5	Horse Power..	6.5	8.5	11.2	13.1	16.3	27.6	32.6	39.1	47.8	62.4
	Cubic Feet.....	777	1023	1345	1568	1942	3273	3884	4602	5706	7440
	Revolutions....	101	88	77	70	64	55	50	44	41	37
6	Horse Power..	8.5	11.2	14.8	17.2	21.4	36.3	42.8	51.4	62.9	82.0
	Cubic Feet.....	851	1121	1473	1717	2128	3587	4256	5109	6247	8152
	Revolutions....	111	96	84	77	70	60	55	47	45	40
7	Horse Power..	10.8	14.2	18.8	21.9	27.0	45.7	54.0	64.8	79.3	103.4
	Cubic Feet.....	920	1211	1592	1857	2290	3875	4598	5520	6760	8817
	Revolutions....	120	104	91	83	77	65	60	50	49	43
8	Horse Power..	13.2	17.3	22.8	26.6	32.9	55.9	65.9	79.2	96.9	126.4
	Cubic Feet.....	983	1295	1701	1978	2457	4143	4914	5898	7214	9415
	Revolutions....	128	111	97	89	81	69	64	54	53	46
9	Horse Power..	15.7	20.7	27.2	31.8	39.3	66.7	78.7	94.5	115.6	150.8
	Cubic Feet.....	1043	1373	1804	2110	2607	4457	5214	6158	7659	9994
	Revolutions....	136	118	103	94	86	74	68	58	56	49
10	Horse Power..	18.4	24.3	31.9	37.2	46.1	78.1	92.2	110.6	135.4	176.7
	Cubic Feet.....	1099	1448	1902	2211	2747	4646	5494	6594	8075	10534
	Revolutions....	143	125	109	100	91	78	71	63	59	52
11	Horse Power..	21.2	28.0	36.8	45.0	53.2	90.2	106.4	127.6	156.2	203.8
	Cubic Feet.....	1153	1518	1995	2324	2882	4857	5764	7783	8472	11057
	Revolutions....	150	132	114	104	95	82	75	67	62	54
12	Horse Power..	24.2	31.9	41.9	49.3	60.6	102.7	121.2	145.4	178.1	232.3
	Cubic Feet.....	1204	1586	2083	2426	3009	5075	6018	7224	8839	11541
	Revolutions....	157	136	119	109	99	85	78	72	65	57
13	Horse Power..	27.3	36.0	47.3	55.1	68.3	115.8	136.6	163.9	200.8	261.9
	Cubic Feet.....	1253	1650	2168	2529	3132	5282	6264	7518	9207	12006
	Revolutions....	163	142	124	114	104	89	81	75	67	59
14	Horse Power..	30.5	40.2	52.8	61.6	76.3	129.5	152.7	183.3	224.4	292.7
	Cubic Feet.....	1300	1713	2251	2622	3251	5481	6502	7800	9555	12461
	Revolutions....	169	148	129	118	107	92	84	78	70	61
15	Horse Power..	33.8	44.6	58.6	68.4	84.7	143.6	169.4	203.2	248.9	324.6
	Cubic Feet.....	1346	1773	2330	2716	3365	5673	6730	8076	9883	12898
	Revolutions....	175	153	133	122	111	97	86	80	72	64
16	Horse Power..	37.3	49.1	64.6	75.3	93.3	158.2	186.6	223.9	274.1	357.7
	Cubic Feet.....	1390	1831	2406	2809	3475	5858	6950	8340	10222	13324
	Revolutions....	181	158	138	126	115	99	90	82	74	66
17	Horse Power..	40.8	53.8	70.7	82.6	102.2	173.1	204.4	245.3	300.3	391.7
	Cubic Feet.....	1433	1888	2480	2893	3583	6041	7166	8598	10532	13733
	Revolutions....	187	162	142	130	118	101	93	85	77	68
18	Horse Power..	44.5	58.6	77.1	89.8	111.3	188.8	222.7	267.3	327.2	426.8
	Cubic Feet.....	1475	1943	2552	2977	3687	6220	7374	8850	10831	14131
	Revolutions....	192	167	146	134	122	104	96	87	79	70
19	Horse Power..	48.3	63.6	83.6	97.5	120.7	209.7	241.5	289.8	354.8	462.8
	Cubic Feet.....	1515	1996	2622	3051	3787	6387	7574	9090	11131	14520
	Revolutions..	197	172	150	137	125	107	98	89	81	72
20	Horse Power..	52.1	68.7	90.3	106.3	130.4	221.1	260.8	313.0	383.3	499.9
	Cubic Feet.....	1554	2048	2690	3136	3885	6553	7770	9325	11421	14900
	Revolutions..	202	176	154	141	128	110	101	91	83	73
21	Horse Power..	56.1	73.9	97.1	116.8	140.3	237.8	280.6	336.7	414.9	534.3
	Cubic Feet.....	1592	2098	2756	3214	3981	6713	7962	9552	11768	15158
	Revolutions....	207	180	158	145	132	112	103	93	85	74

See explanation page 45. Price list page 49.

Table Specially Arranged, Expressly for James Leffel's Improved Double Turbine.

HEAD.	SIZE OF WHEELS.	30½	35	40	44	48	56	61	66	74	87
22	Horse Power..	60.1	79.2	104.1	125.2	150.4	255.1	300.8	361.0	444.8	572.8
	Cubic Feet.....	1630	2147	2821	3393	4074	6851	8148	9798	12049	15510
	Revolutions....	211	185	162	148	135	116	106	95	86	76
23	Horse Power..	64.3	84.7	111.3	133.9	160.8	272.6	321.6	388.1	475.5	612.2
	Cubic Feet.....	1667	2195	2884	3470	4166	7023	8332	10002	12322	15862
	Revolutions....	217	189	165	151	138	118	108	97	88	77
24	Horse Power..	68.5	90.3	118.6	142.7	171.4	290.5	342.8	411 4	506.9	652.7
	Cubic Feet.....	1703	2243	2947	3545	4256	7175	8512	10218	12589	16214
	Revolutions....	221	193	169	155	141	121	110	100	90	79
25	Horse Power..	72.9	96.0	126.1	151.7	182.2	309.1	364.5	437.4	538.9	693.8
	Cubic Feet.....	1738	2289	3007	3618	4344	7325	8688	10428	12847	16544
	Revolutions....	226	197	172	158	144	123	113	102	91	81
26	Horse Power..	77.3	101.8	133.8	160.9	193.3	330.2	386.6	463 9	572.1	734.8
	Cubic Feet.....	1772	2334	3067	3688	4430	7468	8860	10632	13098	16874
	Revolutions....	230	201	176	161	146	126	115	105	93	82
27	Horse Power..	81.8	107.7	141.6	170.3	204.5	346.8	408.1	490.9	604.8	779.0
	Cubic Feet.....	1806	2379	3125	3760	4514	8612	9028	10836	13349	17182
	Revolutions....	235	205	179	164	149	128	117	108	95	84
28	Horse Power..	86.4	113.8	149 5	179.8	216.0	366.1	432.0	518.4	638.6	822.4
	Cubic Feet.....	1838	2422	3182	3826	4597	7749	9194	11028	13587	17511
	Revolutions....	239	208	182	167	152	130	119	110	97	85
29	Horse Power..	91 0	119 9	157.6	189.5	227.6	386.0	455.3	546.4	673.1	867.0
	Cubic Feet.....	1871	2465	3238	3890	4678	7887	9356	11226	13830	17820
	Revolutions....	243	212	168	170	155	132	121	113	99	87
30	Horse Power..	95.8	126.2	165.8	199.5	239.6	406.3	479.2	595.1	708.5	912.3
	Cubic Feet.....	1904	2508	3295	3964	4759	8025	9518	11424	14084	18128
	Pevolutions....	248	216	189	173	157	135	124	115	100	88
31	Horse Power..	100.6	132.6	174.2	209.6	251.6	427.9	503.3	605.1	744.2	958.1
	Cubic Feet.....	1935	2884	3349	4025	4837	8157	9674	11610	14340	18414
	Revolutions....	252	219	192	176	160	137	126	117	102	90
32	Horse Power..	105.5	139.0	182.7	219.7	263.9	440.0	527.9	633.4	780 4	1005.1
	Cubic Feet.....	1966	2590	3403	4093	4915	8330	9830	11796	14533	18722
	Revolutions....	256	223	195	178	162	139	128	120	104	91
33	Horse Power..	110.5	145.6	191 3	230.1	276.4	469.1	552.8	663.4	817.3	1052.4
	Cubic Feet.....	1996	2630	3455	4155	4991	8412	9982	11976	14755	19008
	Revolutions....	260	226	198	181	165	142	130	122	105	93
34	Horse Power..	115.6	152.2	200.1	240.7	289.1	490.2	578.2	693.9	854.8	1100.8
	Cubic Feet.....	2027	2670	3508	4224	5067	8593	10134	12162	14984	19294
	Revolutions....	264	230	201	184	167	144	132	124	107	94
35	Horse Power..	120.8	159.1	209.0	251.4	302.0	512.7	604.0	724.8	893.0	1149.9
	Cubic Feet.....	2057	2709	3560	4282	5142	8731	10284	12342	15205	19580
	Revolutions....	268	233	204	187	170	147	134	126	108	96
36	Horse Power..	125.9	165.9	286.0	262.2	314.9	537.9	629.9	755 8	931.2	1199.2
	Cubic Feet.....	2085	2747	3609	4341	5213	8818	10426	12510	15413	19844
	Revolutions....	271	236	207	189	172	149	136	128	110	97
37	Horse Power.	131.2	172.9	227.1	273.2	328.1	550.6	656.3	787.5	970.2	1249.6
	Cubic Feet.....	2114	2785	3658	4401	5286	8951	10572	12684	15626	20130
	Revolutions....	275	240	210	192	172	150	137	130	111	98
38	Horse Power..	136.6	179.9	236.4	284.4	341.5	580.2	683.1	819.7	1009.9	1300.6
	Cubic Feet.....	2142	2822	3708	4459	5356	9075	10712	12852	15733	20394
	Revolutions....	279	243	212	194	177	153	139	133	113	100
39	Horse Power..	142.0	187.1	245 8	295.6	355.1	612.3	710.1	852.2	1049.9	1352.1
	Cubic Feet.....	2170	2859	3756	4517	5425	9193	10850	13020	16041	20658
	Revolutions....	281	246	215	197	179	155	141	135	114	101
40	Horse Power..	147.7	194.3	255.3	307.1	368.8	629.8	737.7	885.1	1090.5	1404.4
	Cubic Feet.....	2189	2895	3804	4576	5495	9230	10990	13188	16248	20922
	Revolutions....	286	249	218	200	182	157	143	137	116	102

See explanation page 45. Price list page 49.

Head.	6⅝ H.Pr.	6⅝ Rev.	6⅝ C.Ft.	7⅝ H.Pr.	7⅝ Rev.	7⅝ C.Ft.	8¾ H.Pr.	8¾ Rev.	8¾ C.Ft.	10 H.Pr.	10 Rev.	10 C.Ft.	11½ H.Pr.	11½ Rev.	11½ C.Ft.	13¼ H.Pr.	13¼ Rev.	13¼ C.Ft.	15¼ H.Pr.	15¼ Rev.	15¼ C.Ft.
41	7.2	1332	108	9.8	1158	145	12.5	1008	182	17.0	882	246	22.0	767	321	29.0	665	428	37.9	579	556
42	7.4	1348	109	10.0	1163	146	13.0	1020	184	17.6	893	249	22.8	776	324	30.3	674	433	39.0	586	562
43	7.8	1364	110	10.2	1178	148	13.4	1032	186	17.9	903	253	23.7	785	328	31.0	682	438	40.5	593	569
44	8.0	1380	112	10.6	1200	150	14.0	1046	188	18.2	914	256	24.0	794	332	32.0	690	444	42.0	600	576
45	8.3	1396	113	10.9	1212	152	14.4	1058	190	18.5	924	258	24.8	803	336	33.5	698	449	43.6	606	584
46	8.5	1412	114	11.0	1225	153	15.0	1070	191	19.0	934	261	25.6	812	340	35.6	706	454	45.0	613	591
47	8.9	1428	115	11.4	1237	155	15.6	1082	193	19.5	945	264	26.4	821	344	36.4	714	460	47.1	620	596
48	9.2	1442	116	12.0	1252	156	16.1	1092	196	20.4	956	266	27.3	830	348	38.0	720	464	48.6	626	602
49	9.5	1458	117	12.2	1265	157	16.5	1104	198	21.0	965	269	28.0	838	352	39.1	727	469	50.0	633	609
50	9.8	1474	119	12.4	1277	159	17.0	1116	200	21.6	974	272	28.9	847	356	40.3	735	474	52.1	640	616
51	10.1	1490	120	12.8	1289	161	17.5	1128	203	22.0	983	275	29.7	855	360	40.9	743	478	54.3	646	622
52	10.4	1500	121	13.3	1304	162	18.0	1136	204	22.8	994	278	31.6	864	363	41.5	750	482	55.2	652	626
53	10.7	1515	122	13.7	1317	164	18.5	1146	206	23.6	1003	280	32.1	872	366	42.6	757	487	56.4	658	632
54	11.0	1531	123	14.0	1328	165	19.0	1156	208	24.5	1012	283	33.6	880	371	43.6	764	491	58.0	664	638
55	11.3	1546	125	14.5	1342	167	19.6	1166	210	25.4	1021	286	34.0	888	375	44.8	771	495	59.5	670	644
56	11.6	1558	126	15.0	1354	168	20.0	1180	212	26.0	1032	288	34.6	896	378	46.0	778	500	61.3	676	650
57	11.9	1572	127	15.4	1366	170	20.6	1193	213	26.8	1041	291	35.5	904	382	47.4	785	504	62.8	682	656
58	12.2	1588	128	16.0	1378	172	21.0	1203	216	27.6	1050	293	36.4	912	386	48.7	792	509	64.0	688	662
59	12.5	1598	129	16.6	1390	173	21.5	1212	218	28.4	1059	296	37.0	920	390	50.1	799	513	66.0	694	669
60	12.8	1612	130	17.0	1400	174	22.1	1220	220	29.0	1068	298	38.0	928	391	51.3	806	518	68.0	700	674
61	13.0	1625	131	17.3	1412	176	22.5	1230	221	29.8	1077	300	38.9	936	393	52.5	813	523	69.8	706	680
62	13.3	1637	132	17.8	1423	177	23.1	1240	223	30.6	1086	303	40.0	943	396	53.2	819	528	71.5	712	687
63	13.6	1650	133	18.2	1435	179	23.6	1250	226	31.6	1095	306	41.0	951	399	55.0	826	533	73.2	718	693
64	14.0	1664	134	18.5	1449	180	24.5	1260	228	32.0	1102	308	42.3	958	402	56.4	832	535	75.0	724	696
65	14.2	1676	135	19.0	1456	182	25.3	1270	230	33.8	1110	311	43.2	965	405	57.6	838	538	77.0	730	700
66	14.6	1689	136	19.4	1465	184	26.0	1281	232	34.6	1118	314	44.4	973	408	58.9	845	543	79.1	735	706
67	14.7	1702	137	19.8	1478	185	26.6	1290	233	35.0	1127	316	45.0	980	411	60.0	851	547	81.2	740	711
68	15.0	1716	138	20.2	1490	186	27.0	1300	234	35.5	1136	318	46.3	988	414	62.1	858	552	82.2	746	716
69	15.4	1728	139	20.4	1599	188	27.4	1309	236	36.0	1144	321	47.0	995	417	63.9	864	556	83.8	751	720
70	15.9	1740	140	20.7	1511	189	28.0	1318	237	36.7	1152	323	48.5	1002	420	65.0	870	561	85.0	757	725

Head.	6⅝			7⅝			8¾			10			11½			13¼			15½		
	H. Pr.	Rev.	C.Ft.	H. Pr.	Rev.	C.Ft.		Rev.	C.Ft.	H. Pr.	Rev.	C.Ft.	H. Pr.	Rev.	Ct. Ft	H. Pr.	Rev.	C.Ft.	H. Pr.	Rev.	C.Ft.
71	16.3	1752	141	21.3	1533	190	28.5	1327	239	37.6	1160	325	49.6	1009	423	66.1	876	565	86.9	762	730
72	16.5	1776	142	22.0	1534	192	29.0	1336	242	38.2	1170	326	50.5	1016	426	67.3	882	570	89.0	768	738
73	16.8	1778	143	22.5	1545	193	29.6	1345	244	39.0	1178	328	51.6	1023	429	68.5	888	574	91.1	773	742
74	17.0	1790	144	22.8	1556	194	30.8	1354	245	40.8	1186	331	52.7	1030	432	70.0	895	577	93.1	778	748
75	17.5	1802	145	23.5	1566	195	31.4	1363	246	41.0	1194	334	54.6	1037	435	72.4	902	579	95.2	783	753
76	18.0	1814	146	24.0	1576	196	32.0	1374	248	41.6	1202	336	55.0	1044	438	73.2	908	582	97.0	788	758
77	18.4	1826	147	24.5	1586	198	32.5	1383	250	42.4	1201	338	56.0	1051	440	74.8	914	585	99.0	793	764
78	18.7	1838	148	25.0	1597	199	33.0	1392	252	43.0	1218	340	57.0	1058	443	76.0	920	588	101.0	798	770
79	19.0	1850	149	25.5	1608	200	33.6	1400	253	44.0	1226	342	58.1	1065	445	77.4	926	593	103.3	803	774
80	19.5	1862	150	26.0	1618	202	34.0	1408	254	45.0	1234	344	59.0	1072	448	79.1	930	598	105.1	808	778
81	20.0	1874	151	26.5	1626	203	34.8	1417	255	45.8	1242	346	60.5	1078	450	80.5	936	604	106.9	813	782
82	20.4	1886	152	27.0	1636	204	35.6	1424	257	46.6	1250	348	61.6	1084	453	82.0	941	608	108.5	818	786
83	20.8	1898	153	27.5	1646	205	36.5	1433	258	47.2	1257	350	63.0	1090	456	83.5	948	610	110.0	823	790
84	21.0	1908	154	28.0	1656	206	37.1	1444	260	48.1	1264	352	64.1	1098	460	85.0	954	612	112.0	827	796
85	21.4	1919	155	28.5	1666	207	37.7	1452	262	49.0	1272	354	65.9	1105	463	86.6	960	615	114.1	833	801
86	21.8	1930	156	29.0	1674	208	38.2	1461	263	50.0	1280	356	66.2	1111	465	88.0	965	620	116.2	836	805
87	22.2	1941	157	29.5	1684	210	39.0	1469	264	51.0	1287	358	67.3	1118	468	89.6	970	623	118.1	841	809
88	22.6	1952	158	30.0	1694	212	39.7	1478	266	52.0	1294	360	68.6	1124	470	91.1	976	626	120.0	848	814
89	23.1	1963	159	30.4	1704	213	40.3	1486	267	52.8	1301	362	69.4	1129	473	92.5	981	630	122.2	855	820
90	23.6	1974	160	31.1	1714	214	41.0	1495	269	53.6	1308	364	70.8	1135	476	94.1	987	634	124.4	862	826
91	24.0	1985	161	31.6	1724	215	41.5	1504	270	54.4	1315	366	71.9	1140	479	95.6	992	638	126.7	869	830
92	24.3	1996	162	32.0	1734	216	42.2	1512	272	55.3	1322	368	73.2	1148	482	97.0	998	642	129.0	873	834
93	24.8	2007	163	32.6	1743	217	42.8	1520	273	56.0	1329	370	74.1	1155	485	98.5	1004	645	131.1	876	839
94	25.3	2017	164	33.0	1752	218	43.5	1528	275	56.9	1336	372	75.5	1161	488	99.2	1009	648	133.2	880	843
95	25.7	2027	165	33.7	1761	219	44.0	1536	277	58.0	1343	374	76.8	1167	490	102.0	1015	651	135.0	886	847
96	26.2	2038	166	34.2	1772	220	44.5	1544	278	59.1	1350	376	78.1	1174	492	104.2	1020	654	137.8	889	852
97	26.5	2049	167	34.9	1780	221	45.1	1552	280	60.0	1357	378	79.1	1180	494	105.8	1025	657	140.0	893	856
98	26.8	2060	168	35.5	1789	222	46.0	1560	281	61.0	1364	380	80.4	1186	497	107.2	1030	660	142.2	897	860
99	27.0	2070	169	36.0	1797	224	46.9	1568	283	62.1	1371	382	82.0	1192	500	109.1	1035	664	144.2	900	864
100	27.3	2080	170	36.6	1808	226	48.0	1576	285	64.0	1378	384	83.2	1198	502	110.8	1040	668	146.1	904	868

Continuation of table from page 38. Price page 49.

TABLE FOR MINING WHEELS FROM 10 TO 20 INCHES DIAMETER.

SHOWING HORSE POWER, CUBIC FEET OF WATER, AND REVOLUTIONS PER MINUTE, FROM 41 TO 100 FEET HEAD.

[The first horizontal line gives size and number of Wheels.]

	10—No. 2.			10—No. 1.			10.			13¼—No. 1.		
HEAD.	H. P.	REV.	C. FT.	H. P.	REV.	C. FT.	H. P.	REV.	C. FT.	H. P.	REV.	C. FT.
41	9.8	882	145	12.5	882	182	17.0	882	246	22.0	665	321
42	10.0	893	146	13.0	893	184	17.6	893	249	22.8	674	324
43	10.2	903	148	13.4	903	186	17.9	903	253	23.7	682	328
44	10.6	914	150	14.0	914	188	18.2	914	256	24.0	690	332
45	10.9	924	152	14.4	924	190	18.5	924	258	24.8	698	336
46	11.0	934	153	15.0	934	191	19.0	934	261	25.6	706	340
47	11.4	945	155	15.6	945	193	19.5	945	264	26.4	714	344
48	12.0	956	156	16.1	956	196	20.4	956	266	27.3	720	348
49	12.2	965	157	16.5	965	198	21.0	965	269	28.0	727	352
50	12.4	974	159	17.0	974	200	21.6	974	272	28.9	735	356
51	12.8	983	161	17.5	983	203	22.0	983	275	29.7	743	360
52	13.3	994	162	18.0	994	204	22.8	994	278	31.6	750	363
53	13.7	1003	164	18.5	1003	206	23.6	1003	280	32.1	757	366
54	14.0	1012	165	19.0	1012	208	24.5	1012	283	33.6	764	371
55	14.5	1021	167	19.6	1021	210	25.4	1021	286	34.0	771	375
56	15.0	1032	168	20.0	1032	212	26.0	1032	288	34.6	778	378
57	15.4	1041	170	20.6	1041	213	26.8	1041	291	35.5	785	382
58	16.0	1050	172	21.0	1050	216	27.6	1050	293	36.4	792	386
59	16.6	1059	173	21.5	1059	218	28.4	1059	296	37.0	799	390
60	17.0	1068	174	22.1	1068	220	29.0	1068	298	38.0	806	391
61	17.3	1077	176	22.5	1077	221	29.8	1077	300	38.9	813	393
62	17.8	1086	177	23.1	1086	223	30.6	1086	303	40.0	819	396
63	18.2	1095	179	23.6	1095	226	31.6	1095	306	41.0	826	399
64	18.5	1102	180	24.5	1102	228	32.0	1102	308	42.3	832	402
65	19.0	1110	182	25.3	1110	230	33.8	1110	311	43.2	838	405
66	19.4	1118	184	26.0	1118	232	34.6	1118	314	44.4	845	408
67	19.8	1127	185	26.6	1127	233	35.0	1127	316	45.0	851	411
68	20.2	1136	186	27.0	1136	234	35.5	1136	318	46.3	858	414
69	20.4	1144	188	27.4	1144	236	36.0	1144	321	47.0	864	417
70	20.7	1152	189	28.0	1152	237	36.7	1152	323	48.5	870	420
71	21.3	1160	190	28.5	1160	239	37.6	1160	325	49.6	876	423
72	22.0	1170	192	29.0	1170	242	38.2	1170	326	50.5	882	426
73	22.5	1178	193	29.6	1178	244	39.0	1178	328	51.6	888	429
74	22.8	1186	194	30.8	1186	245	40.8	1186	331	52.7	895	432
75	23.5	1194	195	31.4	1194	246	41.0	1194	334	54.6	902	435
76	24.0	1202	196	32 0	1202	248	41.6	1202	336	55.0	908	438
77	24.5	1210	198	32.5	1210	250	42.4	1210	338	56.0	914	440
78	25.0	1218	199	33.0	1218	252	43.0	1218	340	57.0	920	443
79	25.5	1226	200	33.6	1226	253	44.0	1226	342	58.1	926	445
80	26.0	1234	202	34.0	1234	254	45.0	1234	344	59.0	930	448
81	26.5	1242	203	34.8	1242	255	45.8	1242	346	60.5	936	450
82	27.0	1250	204	35.6	1250	257	46.6	1250	348	61.6	941	453
83	27.5	1257	205	36.5	1257	258	47.2	1257	350	63.0	948	456
84	28.0	1264	206	37.1	1264	260	48.1	1264	352	64.1	954	460
85	28.5	1272	207	37.7	1272	262	49.0	1272	354	65 9	960	463
86	29.0	1280	208	38.2	1280	263	50.0	1280	356	66.2	965	465
87	29.5	1287	210	39.0	1287	264	51.0	1287	358	67.3	970	468
88	30.0	1294	212	39.7	1294	266	52.0	1294	360	68.6	976	470
89	30.4	1301	213	40.3	1301	267	52.8	1301	362	69 4	981	473
90	31.1	1308	214	41.0	1308	269	53 6	1308	364	70.8	987	476
91	31.6	1315	215	41.5	1315	270	54.4	1315	366	71.9	992	479
92	32.0	1322	216	42.2	1322	272	55.3	1322	368	73.2	998	482
93	32.6	1329	217	42.8	1329	273	56.0	1329	370	74.1	1004	485
94	33.0	1336	218	43.5	1336	275	56.9	1336	372	75.5	1009	488
95	33.7	1343	219	44.0	1343	277	58.0	1343	374	76.8	1015	490
96	34.2	1350	220	44.5	1350	278	59.1	1350	376	78 1	1020	492
97	34.9	1357	221	45.1	1357	280	60 0	1357	378	79.1	1025	494
98	35.5	1364	222	46.0	1364	281	61.0	1364	380	80.4	1030	497
99	36.0	1371	224	46.9	1371	283	62.1	1371	382	82.0	1035	500
100	36.6	1378	226	48.0	1378	285	64.0	1378	384	83.2	1040	502

Explanation page 47. Description page 18. Price page 49.

TABLE FOR MINING WHEELS FROM 10 TO 20 INCHES DIAMETER.—Continued.

[The first horizontal line gives size and number of Wheels.]

	13¼.			15¼.			17½.			20.		
HEAD.	H. P.	REV.	C. FT.	H. P.	REV.	C. FT.	H. P.	REV.	C. FT.	H. P.	REV.	C. FT.
41	29.0	665	428	37.9	579	556	50 0	504	728	68.6	441	984
42	30.3	674	433	39.0	586	562	52.0	510	736	70 4	446	997
43	31.0	682	438	40.5	593	569	54 6	516	744	71.6	451	1012
44	32.0	690	444	42 0	600	576	56.0	523	752	72.8	457	1024
45	33.5	698	449	43 6	606	584	57.6	529	758	74.0	462	1032
46	35.6	706	454	45.0	613	591	60.0	535	764	76.1	467	1044
47	36.4	714	460	47.1	620	596	62.4	541	772	78 1	472	1056
48	38.0	720	464	48.6	626	602	64.4	546	782	81.4	478	1064
49	39.1	727	469	50.0	633	609	66.0	552	792	84.0	482	1076
50	40.3	735	474	52.1	640	616	68.1	558	800	86.4	487	1088
51	40.9	743	478	54 3	646	622	70.0	564	812	88.1	491	1100
52	41.5	750	482	55.2	652	626	72 2	568	816	91.2	497	1112
53	42.6	757	487	56.4	658	632	74.0	573	824	94.4	501	1122
54	43.6	764	491	58.0	664	638	76.2	578	832	98.0	506	1132
55	44.8	771	495	59.5	670	644	78.4	583	840	101.6	510	1142
56	46.0	778	500	61.3	676	650	80.2	589	848	104.0	516	1152
57	47.4	785	504	62.8	682	656	82.4	597	852	107.2	520	1163
58	48.7	792	509	64.0	688	662	84.2	602	860	110.4	525	1172
59	50.1	799	513	66.0	694	669	86.0	606	870	113.6	529	1183
60	51.3	806	518	68.0	700	674	88.3	610	880	116.0	534	1192
61	52.5	813	523	69.8	706	680	90.0	615	885	119.2	538	1201
62	53.2	819	528	71.5	712	687	92.2	620	892	122.4	543	1212
63	55.0	826	533	73.2	718	693	94.3	625	902	126.2	548	1224
64	56.4	832	535	75.0	724	696	97.7	630	912	129.3	551	1235
65	57.6	838	538	77.0	730	700	101.0	635	921	135.0	555	1244
66	58.9	845	543	79.1	735	706	104.2	640	929	138.4	559	1255
67	60.0	851	547	81.2	740	711	106.5	645	933	140.8	563	1264
68	62.1	858	552	82.2	746	716	108.0	650	936	142.2	568	1273
69	63.9	864	556	83.8	751	720	109.7	655	942	144.3	572	1283
70	65.0	870	561	85.0	757	725	112.0	659	948	146.8	576	1292
71	66.1	876	565	86.9	762	730	114.0	664	956	149.4	580	1300
72	67.3	882	570	89.0	768	738	116 1	668	967	152.8	585	1308
73	68.5	888	574	91.1	773	742	118.4	672	976	156.3	589	1316
74	70.0	895	577	93.1	778	748	122.8	677	982	161 0	593	1324
75	72.4	902	579	95.2	783	753	125.5	681	985	164.1	597	1336
76	73.2	908	582	97.0	788	758	128.0	687	992	167.4	601	1344
77	74.8	914	585	99.0	793	764	130.3	691	1000	170.5	605	1352
78	76.0	920	588	101.0	798	770	132.2	696	1008	174.0	609	1360
79	77.4	926	593	103.3	803	774	134.5	700	1013	177.2	613	1368
80	79.1	930	598	105.1	808	778	136.2	704	1016	180.1	617	1376
81	80.5	936	604	106.9	813	782	139.0	708	1020	183.2	622	1384
82	82.0	941	608	108.5	818	786	142.3	712	1028	186.4	625	1392
83	83.5	948	610	110.0	823	790	146.0	716	1032	189.2	628	1400
84	85.0	954	612	112.0	827	796	148.4	721	1040	192.5	632	1408
85	86.6	960	615	114.1	833	801	150.8	726	1048	196.2	636	1416
86	88.0	965	620	116.2	836	805	152.7	731	1052	200.0	640	1424
87	89.6	970	623	118.1	841	809	155.5	735	1056	203.8	643	1432
88	91.1	976	626	120.0	848	814	158.7	739	1063	207.5	646	1440
89	92.5	981	630	122.2	855	820	161.2	743	1068	211.4	650	1448
90	94.1	987	634	124.4	862	826	164.0	747	1075	214.2	654	1456
91	95.6	992	638	126.7	869	830	166.2	752	1080	217.6	657	1464
92	97.0	998	642	129.0	873	834	168 8	757	1088	221.2	661	1472
93	98.5	1004	645	131.1	876	839	171.2	760	1092	224.0	664	1480
94	99.2	1009	648	133.2	880	843	174.0	764	1098	227.6	668	1488
95	102.0	1015	651	135.0	886	847	176.3	768	1107	232.0	671	1496
96	104.2	1020	654	137.8	889	852	178.0	772	1112	236.4	675	1504
97	105.8	1025	657	140.0	893	856	180.2	776	1120	240.0	678	1512
98	107.2	1030	660	142.2	897	860	183.0	780	1126	244.2	682	1520
99	109.1	1035	664	144.2	900	864	186.8	784	1132	248.4	685	1528
100	110.8	1040	668	146.1	904	868	191.2	788	1140	252.7	689	1536

Explanation page 47. Description page 18. Price page 49.

Table of Leffel's New Special Double Turbine.

No. 2 Wheel.				No. 3 Wheel.				No. 4 Wheel.				No. 5 Wheel.			
1235 Sq. Inches Issue.				841 Sq. Inches Issue.				712 Sq. Inches Issue.				606 Sq. Inches Issue.			
H'd.	H. P.	C. Ft.	Rev.	H'd.	H. P.	C. Ft.	Rev.	H'd.	H. P.	C. Ft.	Rev.	H'd.	H. P.	C. Ft.	Rev.
1	6.8	4125	16	**1**	4.7	2807	19	**2**	11.2	3364	29	**2**	9.6	2862	32
2	19.5	5833	22	**2**	13.3	3969	25	**3**	20.5	4119	35	**3**	17.5	3512	38
3	35.6	7143	27	**3**	24.3	4863	31	**4**	31.6	4755	40	**4**	26.9	4055	44
4	55.0	8247	31	**4**	37.4	5614	36	**5**	44.3	5316	44	**5**	37.7	4533	50
5	76.8	9221	35	**5**	52.3	6277	41	**6**	58.5	5822	48	**6**	49.9	4965	55
6	101.5	10098	38	**6**	69.1	6874	44	**7**	74.3	6293	51	**7**	63.3	5367	60
7	128.9	10914	41	**7**	87.8	7429	49	**8**	90.2	6724	55	**8**	76.9	5734	65
8	156.3	11661	44	**8**	106.4	7938	52	**9**	107.6	7131	59	**9**	91.6	6082	69
9	186.5	12367	47	**9**	127.0	8418	55	**10**	126.1	7518	63	**10**	107.5	6411	72
10	218.7	13039	50	**10**	148.9	8876	59	**11**	145.5	7886	67	**11**	123.9	6725	75
11	252.3	13777	52	**11**	171.8	9310	61	**12**	165.7	8234	71	**12**	141.2	7022	78
12	287.3	14280	54	**12**	195.6	9720	64	**13**	187.0	8570	75	**13**	159.3	7308	81
13	324.3	14863	56	**13**	220.8	10117	67	**14**	208.7	8898	78	**14**	177.9	7587	84
14	362.0	15432	58	**14**	246.4	10505	70	**15**	231.7	9210	81	**15**	197.5	7854	87

H'd.—Head in ft. H. P.—Horse Power. C. Ft.—Cubic ft. per min. Rev.—Revolutions per min.

Explanation page 47. Dimensions page 33. Price page 49.

No. 6 Wheel.				No. 7 Wheel.				No. 8 Wheel.				No. 9 Wheel.			
514 Sq. Inches Issue.				403 Sq. Inches Issue.				303 Sq. Inches Issue.				264 Sq. Inches Issue.			
H'd.	H. P.	C. Ft.	Rev.	H'd.	H. P.	C. Ft.	Rev.	H'd.	H. P.	C. Ft.	Rev.	H'd.	H. P.	C. Ft.	Rev.
2	8.1	2428	35	**2**	6.3	1901	38	**3**	8.8	1757	55	**3**	7.6	1522	58
3	14.8	2975	41	**3**	11.6	2330	46	**4**	13.5	2028	62	**4**	11.7	1757	67
4	23.0	3435	47	**4**	17.9	2690	54	**5**	18.9	2268	69	**5**	16.3	1965	76
5	32.0	3841	53	**5**	25.0	3008	61	**6**	25.0	2484	76	**6**	21.6	2152	83
6	42.3	4206	58	**6**	33.1	3294	68	**7**	31.9	2684	82	**7**	27.4	2326	90
7	53.7	4546	63	**7**	42.0	3560	73	**8**	38.5	2868	88	**8**	32.4	2485	96
8	65.1	4857	68	**8**	50.9	3803	78	**9**	45.9	3042	93	**9**	39.8	2636	102
9	77.7	5151	73	**9**	60.7	4034	83	**10**	53.9	3206	98	**10**	46.6	2779	107
10	91.1	5431	77	**10**	71.3	4253	87	**11**	62.1	3363	103	**11**	53.7	2914	112
11	105.1	5797	81	**11**	82.2	4461	91	**12**	70.8	3512	108	**12**	61.1	3044	118
12	119.7	5948	84	**12**	93.6	4657	95	**13**	79.8	3655	113	**13**	69.1	3168	123
13	135.1	6191	88	**13**	105.7	4848	99	**14**	89.1	3795	118	**14**	77.2	3289	128
14	150.8	6428	92	**14**	118.1	5033	103	**15**	98.9	3929	123	**15**	85.6	3404	132
15	167.4	6653	96	**15**	130.9	5210	106	**16**	109.0	4056	127	**16**	94.3	3516	136

H'd.—Head in ft. H. P.—Horse Power. C. Ft.—Cubic ft. per min. Rev.—Revolutions per min.

Explanation of table page 47. Prices page 49. Dimensions page 33

Table of Leffel's New Special Double Turbine.

No. 10 Wheel. 200 Sq. Inches Issue.				No. 11 Wheel. 150 Sq. Inches Issue.				No. 12 Wheel. 113 Sq. Inches Issue.				No. 13 Wheel. 85 Sq. Inches Issue.			
H'd.	H. P.	C. Ft.	Rev.	H'd.	H. P.	C. Ft.	Rev.	H'd.	H. P.	C. Ft.	Rev.	H'd.	H. P.	C. Ft.	Rev.
4	8.9	1337	78	**4**	6.6	985	89	**5**	7.0	841	115	**6**	6.9	687	146
5	12.4	1494	87	**5**	9.0	1102	100	**6**	9.2	921	126	**7**	8.8	743	158
6	16.4	1637	95	**6**	12.1	1206	110	**7**	11.6	995	137	**8**	10.7	794	168
7	20.8	1769	103	**7**	15.3	1305	120	**8**	14.2	1063	147	**9**	12.7	842	178
8	25.3	1890	110	**8**	17.9	1394	129	**9**	16.9	1128	155	**10**	14.9	888	188
9	30.2	2005	116	**9**	22.4	1479	137	**10**	19.9	1189	164	**11**	17.2	931	197
10	35.4	2113	124	**10**	26.1	1558	143	**11**	22.9	1247	173	**12**	19.6	972	207
11	40.8	2217	130	**11**	30.1	1634	149	**12**	26.1	1302	181	**13**	22.1	1012	215
12	46.5	2315	135	**12**	34.3	1708	156	**13**	29.5	1355	188	**14**	24.7	1052	223
13	52.5	2409	140	**13**	38.8	1778	162	**14**	33.0	1406	194	**15**	27.3	1087	231
14	58.6	2501	146	**14**	43.3	1844	168	**15**	36.5	1456	200	**16**	30.2	1123	238
15	65.1	2589	151	**15**	48.1	1908	174	**16**	40.3	1504	206	**17**	33.0	1157	245
16	71.7	2673	156	**16**	53.0	1972	180	**17**	44.1	1550	212	**18**	36.0	1191	253
17	78.5	2756	161	**17**	57.9	2033	186	**18**	48.1	1597	218	**19**	39.1	1224	260
18	85.6	2836	166	**18**	63.2	2181	191	**19**	52.2	1639	225	**20**	42.1	1255	267

H'd.—Head in ft. H. P.—Horse Power. C. Ft.—Cubic ft. per min. Rev.—Revolutions per min.

Explanation page 47. Dimension page 33. Price page 49.

James Leffel's New Special Double Turbine.

We have been manufacturing with perfect success for some time, several special size Leffel Wheels; tables of which are presented herewith on foregoing pages 42, 43 and 44. It will be observed that a large additional quantity of water is applied to them, over that used on the common or standard sizes; and that there is also a corresponding increase of power. In fact it is in every way perfectly reliable and fully warranted in every particular.

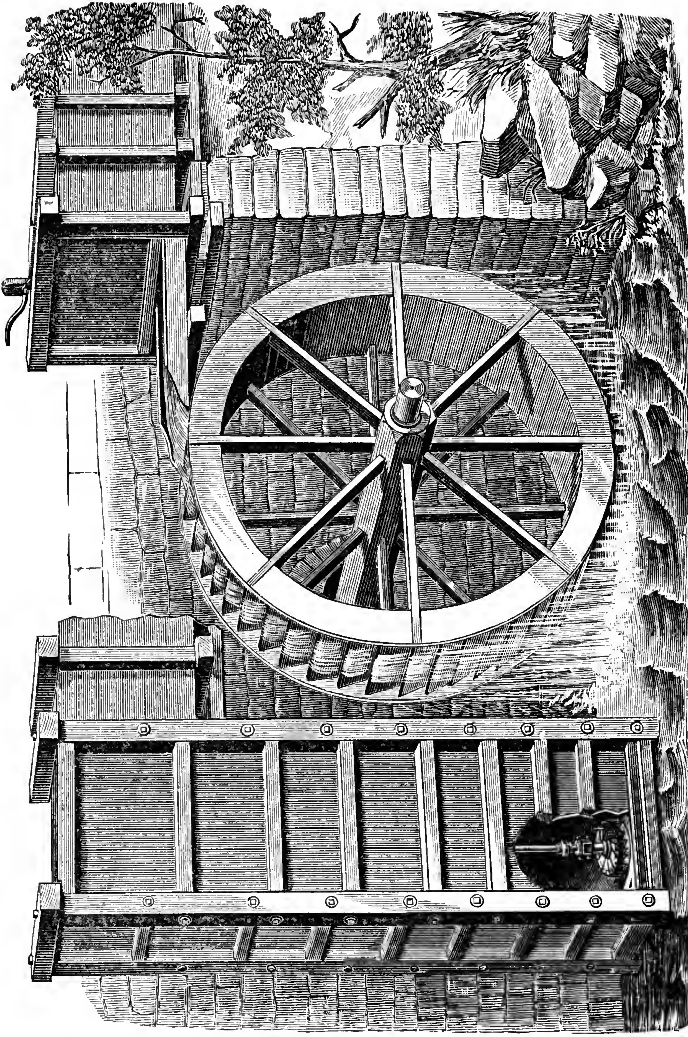
We can give a large number of names of reliable parties each using from one to four or more of them, as there are now over 600 of them in daily operation. Their durability and efficiency has been amply tested and thoroughly proven in every respect by their constant practical work, driving all kind of machinery. No complaint whatever has been made of them from any source. In fact they are made precisely as the common sizes, except that the gates and buckets are made wider to admit more water, but the same curves and proportions are retained.

The table gives quantity of water discharged per minute in cubic feet, the number of revolutions per minute, the horse power and number of square inches vent; all of which will be understood upon examination.

Explanation of Tables of Standard Wheels.

On pages 34, 35, 36 and 37 will be found tables showing the power, number of revolutions per minute, and also the number of cubic feet of water discharged per minute, for each size of our Wheels, under heads from 3 to 40 feet. The top lines of figures show the size of wheels from 6⅝ to 87 inches diameter. The left hand perpendicular columns give the head of water in feet from 3 to 21, and 21 to 40. In the small squares formed by intersection of the perpendicular and horizontal lines are three sets of figures. The upper one indicates the number of horse-power; the middle set of figures shows the number of cubic feet of water used by the wheel per minute, and the lower set of figures shows the number of revolutions of wheel per minute. The style and arrangement of table was first introduced by James Leffel, and on account of its simplicity, compactness, beauty and convenience of reference, has been extensively copied and adopted by other wheel men.

On pages 38 and 39 tables for small wheels are given, under heads ranging from 40 to 100 feet. The first or upper horizontal column represents the sizes of wheels in inches, and parts of inches, and the first left hand perpendicular column represents the amount of head under which each operates. The horizontal lines of figures in the body of the table, shows the horse power, revolutions per minute while at labor, and cubic feet of water discharged per minute, all of which will be understood.



Explanation of Tables of Mining Wheels.

On pages 40 and 41 will be found a table showing tne power, quantity of water, and revolutions per minute of eight sizes of our new mining wheel. The same method of arranging the sizes and heads is observed as in the preceding pages ; but the powers, water used, and revolutions, are upon the same horizontal line. An examination will readily enable any one to obtain the desired data.

Explanation of Tables of New Special Wheels.

On pages 42, 43 and 44, will be found tables for our New Special Leffel Wheel. The first horizontal line running lengthwise with each page, represents the size or number of wheel, and does not give it in inches as heretofore. The second horizontal line gives square inches' vent of each number of wheel in that table ; while the third horizontal line shows the abbreviated words, for "Head, Horse Power, Cubic Feet and Revolutions." After this in each table, four heavy perpendicular columns will be observed, representing the heads in feet ; and between these columns are others in lighter figures, the one next the heavy column showing the horse power, the next one the cubic feet of water used per minute, and the last or next the heavy column again the revolutions per minute. It should be observed that each of the wheels has a column, representing the head, and that these columns are not the same for all. An examination cannot fail to make the tables clearly understood by any one.

Revolution of Wheels While at Labor.

The revolutions of the wheels, as laid down in the foregoing tables, are the number of revolutions the wheel makes when at work. But as there is always a loss of fall by the water drawing down in the head race, and also rising in the tail race, when the wheel is running, we would advise those who have charge of putting in the wheels, that, in calculating for the speed of wheel and machinery, they always base their calculations on a fall of from six inches to a foot less than the measured fall, when the head and fall is from four to twenty feet, and eighteen inches when the fall is over twenty feet ; thus allowing for the loss of head mentioned, which will bring the speed of the wheel to suit the actual running head.

Explanation of Plate on Foregoing Page.

The plate on page 46 is intended to clearly show some of the reasons why an overshot wheel, even of the best construction will not yeld the full power of the water applied to it. At the same time we shiow how our wheel must necessarily produce an increased power by reason of its being free from all those objections which, in the nature of an overshot, result from its construction, and largely diminish its efficiency as a motor by an unavoidable waste of water and loss of a part of the entire fall.

For the purpose of illustration, we have selected a head and fall of eighteen feet, being the medium and most common fall for overshot wheels. As it is usual to allow a head of water of about two feet, above the overshot wheel, and to prevent the wading of the wheel in tail-water, it is necessary to allow a clearance of at least six inches, the wheel therefore for this fall can not exceed fifteen feet six inches diameter. We will point out severally the sources from which a waste of water arises. It has generally been the practice to regard the entire head of water above the overshot as wholly lost, but we will concede the benefit of one-half of the head. There will then remain to be deducted from the whole fall—1st, one foot above the wheel; 2nd, one foot for depth of rim, which below will be a line where the buckets are entirely empty; 3rd, six inches clearance below the wheel; which makes together a loss of two feet six inches fall; and as the water begins to empty from the buckets at some distance above the water in the tail-race, which not unfrequently is nearly on a level with the shaft of the wheel, particularly when the buckets are well-filled, it will be safe to say that the waste of water from this source will be fully equivalent to the loss of another foot of fall, which added to the amount of fall lost in the manner before described, will make a total loss of three feet six inches out of eighteen feet, or nearly twenty per cent. of the whole fall.

It will be seen, that our wheel is placed at the botton of the penstock, and touching the tail water; thus utilizing every inch of the fall below the overshot, if the pit under the turbine be of sufficient depth and capacity. A line drawn through the top of the penstock, at the height of the level of the head water in the forbay over the overshot, would also show that there is no loss at the head surface; as the water should stand at almost a perfect level, providing also the forbay leading to the penstock is of sufficient capacity.

In another particular we have also demonstrated their superiority over the overshot, this being in the height of head to which they may be applied. There are a number of instances in which the Leffel has been supplied, where the height of head water was so excessive, and the surroundings so difficult, that the overshot could not be used or applied in any form or manner. In fact, there is a limit as to the diameter of the overshot, and beyond which they become impracticable; this circumstance only adding to the utility of our wheel, and its excellence being more apparent with increase of head.

Does the Work with Half the Water.

LEIPSIC, MICH., March 26, 1885.

James Leffel & Co.:

GENTS—Yours of 24th just to hand and contents noted. We are using your 26½ inch Wheel to run 4 ft. burr stone with 10 ft. head. We used it last fall, when water was low, on 8 foot head with ½ gate, grinding 10 bushels wheat per hour. We are well pleased with its work. We have other wheels but this one will do the work with half the water of the other wheels. Yours truly,

HIGLEY & CLEPMAN.

PRICE LIST OF JAMES LEFFEL'S STANDARD WHEELS.

Size.	Wheels.	Globes.	Vent.
6⅝	$ 180	$ 75	4.9
7⅝	185	78	6½
8¾	190	81	8¾
10	195	85	11¼
11½	200	90	14⅔
13¼	210	100	19¾
15¼	185	115	26¼
17½	195	130	34½
20	205	150	45
23	225	175	59½
26½	265	205	79
30½	300		104
35	335		137
40	385		180
44	425		217
48	500		259
56	720		441
61	815		518
66	940		624
74	1200		769
87	1600		991

REMARKS.

All the *Standard* Wheels up to 35 inches diam. have Steel Gates.

All wheels up to 15½ inches diam. are Brass except the Guide Casing, which is Iron.

The Guide Casings are the upper and lower plates and fixtures shown on page 13.

See pages 12 and 13 for description of Wheel and cut of same.

See pages 22 and 23 for cut and explanation of Globes.

See pages 34, 35, 36, 37, 38, 39, and 45 for tables and explanation of tables for Standard Wheels.

See pages 26 and 27 for dimensions.

We must always know which way Wheel runs, whether *with* or *against* sun, *Right* or *Left* Hand.

PRICE LIST OF LEFFEL'S IMPROVED SPECIAL WHEELS.

Size.	No.	Price.	Vent.
23	No. 13	$ 235	85
26½	" 12	275	113
30½	" 11	315	150
35	" 10	350	200
40	" 9	400	264
44	" 8	440	303
50	" 7	550	403
56	" 6	750	514
61	" 5	850	606
66	" 4	980	712
74	" 3	1250	841
87	" 2	1650	1235

REMARKS.

All these Improved Special Wheels up to 35 inches diam. have Steel Gates.

See page 45 for description.

See pages 42, 43, 44 and 47 for tables and explanation of same for special wheels.

See pages 32 and 33 for dimensions of Special Wheels.

State whether Wheel must run *with* or *against* sun.

PRICE LIST OF LEFFEL'S IMPROVED MINING WHEELS.

Size.	No.	Price.	Vent.
10	No. Two	$ 330	6½
10	" One	375	8¾
10		375	11½
13¼	" One	430	14⅔
13¼		430	19¾
15¼		430	26¼
17½		500	34½
20		500	45

REMARKS.

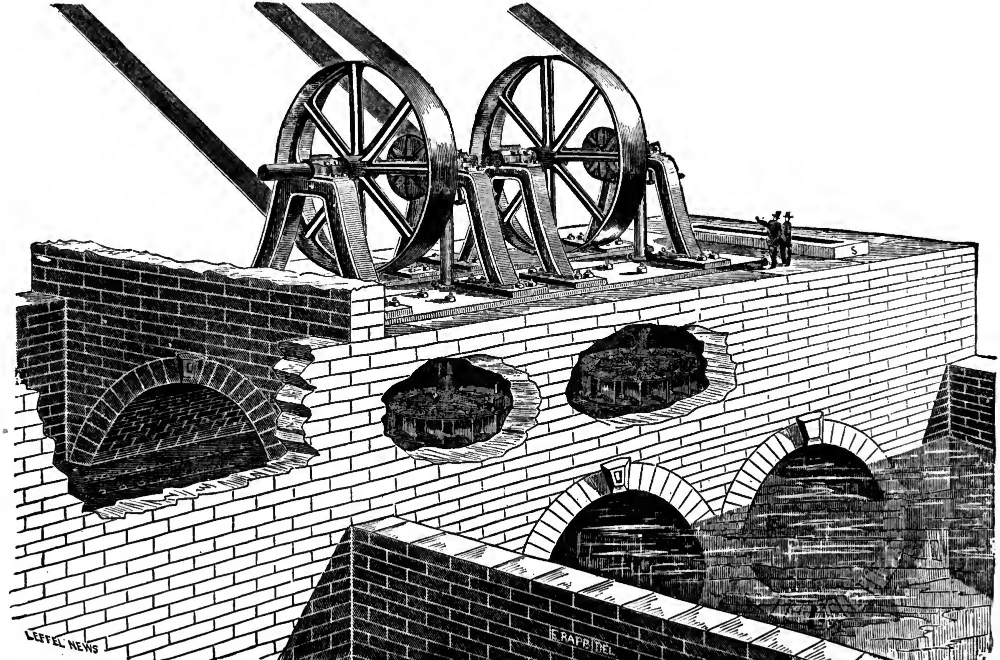
All these Improved Mining Wheels are made with Steel Gates and Iron Guide Cases.

All are made with Brass Wheels, up to 15¼ inches diam.

See pages 18 and 19 for illustration and description. See pages 28 and 29 for dimensions.

See pages 40, 41 and 47 for tables and explanation.

State plainly in ordering whether side or edge of Wheel next observer (cut page 19) must run *Up* or *Down*.


LEFFEL NEWS
E. RAPP DEL.

A Mammoth Cotton Mill Driven by Leffel Wheels.

The plate on the opposite page represents the arrangement and method adopted by the Manville Cotton Company, Albion, R. I., for locating our wheels in their new mill, and connecting them to the machinery. The flumes or penstocks are constructed of stone, brick and iron throughout, one situated in each end of the mill; the floors being iron and supported by iron girders or sills. The arches, or flumes proper, in which the wheels are located, are made of bricks, with the sides laid up with heavy cut stones; in the tops or deckings at S, is a safety vent for overflow of water, thereby relieving the undue pressure in case the wheels should be suddenly closed at any time. The arches for discharge of water in tail-race are each 11 feet high, by 20 feet wide, having in them a standing depth of 7 feet tail-water, there being iron draft tubes extending down from the wheels. The entire penstocks are each 40 by 80 feet, containing two of our 84 inch wheels in each, under a head of over 18 feet, giving about 1,740 horse power.

The power of these wheels is delivered from one side of the crown gear to the jack shaft by means of jack gear 59 inches diameter, and 38 cogs, working into the crown gear. The jack shaft is 8 inches diameter, and consists of two lengths, connected with 24-inch face couplings. The first length from the wheel is 7 feet 4 inches; the second is 14 feet for the two inside wheels, and 15 feet 2 inches for the outside. Upon the second length, resting in two bearings, are the fly-wheels, or main driving pulleys, 20 feet diameter, 25 inch face, weighing 20,368 pounds each.

This mill has a capacity of 120,000 spindles and 2,112 looms, equipped and fitted for the manufacture of fine sheetings and shirtings. In exterior dimensions it is 783 feet long and 98 feet wide, with six towers adjoining, each 26 feet square. This is exclusive of an engine and boiler building 100 feet long and 94 feet wide, adjoining the main building on the south end, and having a chimney 16 feet square and 155 feet high. The mill has five full floors for machinery. It covers an area on the ground of over two acres, and the aggregate area of the floors, inside the brick walls, is about nine acres. Some idea of the magnitude of the works may be gained from the fact that in the construction of the building there were required 8,160 cords of rough stone, 9,110 cubic feet of granite ashler, 5,605,800 brick, 348,028 pounds of cast iron, and nearly 23,000 pounds of wrought and malleable iron. There are 117,351 square feet of roofing, and 1,208 windows, containing 34,994 lights of glass, and requiring 94,104 pounds of window weights. There are 41,971 yards of plastering. Over 860,000 feet of southern hard pine timber was used; and in the floors there are 1,266,000 feet of 3-inch spruce planks and 65,000 pounds of nails.

The principal motive power of the mill is water, received from the Blackstone river, the flow of which is 38,000 cubic feet per minute. For a period of from five to eight months of the year the flow

of water at mean average is about 65,000 cubic feet, constituting a full supply for the mill. During the remaining part, or dry season, of the year, water as the motive power is supplemented by steam to the extent of one-half the capacity of the mill, or 800 horse power.

At a point 282 feet north of the mill is located the dam, which was built in 1867 by the late S. B. Cushing, C. E. Providence. This dam is a fine work, built upon a rock bed, and constructed with cut granite, laid in bed and build courses. It has a span of 246 feet between buttresses. The face of the dam is concaved to the arc of a circle of 511 feet radius. The height from the foundation to the top of cap-log is 16 feet. The available fall or working head is 18 feet 6 inches. From the basin or pond the water passes into a trench 14 feet deep, extending 61 feet to a stone bulkhead 64 feet long, having ten gates fitted with heavy gearing and hoisting apparatus. From this point the water passes into a large basin of 37,800 feet area, and at the end of which are the guard-racks, with a length or breast of 180 feet. The front of the racks is pitched to an angle of 68 degrees, having 2,880 feet area or surface for screening.

The principal trenches or water-ways have a cross-sectional area of 474 feet. The water necessary to supply the wheels, in passing through this large space, is required to move with a velocity of 1¾ feet per second. To the entrance of each flume are two gates, built of 4-inch oak plank, bolted, strapped with iron plates, and hung upon one edge or side. The arrangement of the flumes and connections is such that, if desired, either one of the four wheels may be stopped, the flume drawn off, the wheel or step inspected, the flume again filled, and the wheel started in less than thirty minutes from the time of stopping, during which time the other wheels are in full operation.

The engraving shows two Leffel wheels in position in the flume. The Manville Company are, however, using six of these wheels, manufactured by James Leffel & Co,, Springfield, Ohio. The wheels shown in the illustration are each 84-inch, working, as already stated, under 18½ feet head. They are set 13 feet under the head, with 5 or 6 inches draft tube. The vertical shafts for wheels are 8 inches diameter, hammered iron, and consist of two parts joined together 20 inches below the top of the flume, with clutch couplings, the upper piece extending through a 20-inch tube in the brick arch.

Mining Wheel Running 20 Stamp Mill 1-2 Gate.

VIRGINIA CITY, M. T., April 4th, 1885.

James Leffel & Co., Springfield, Ohio:

GENTS—The 23 inch Mining Wheel purchased from you during the year 1884 we are using under a 30 foot head of water, in operating our Quartz Mill, located at Pony, Madison County, Montana Territory, consisting of 20 stamps, bleeke crushers, 7x10, and four forerunners. The wheel under this head would furnish twice the amount of power necessary to operate the machinery named. The power and simplicity of your wheel in our estimation cannot be excelled.

HENRY ELLING.

Useful Facts in Hydraulics.

Doubling the diameter of a pipe increases the capacity four times.

The ordinary speed to run a pump is 100 feet of piston per minute.

To find the area of a piston, square the diameter and multiply by .7854.

Each nominal horse power of boilers requires 1 cubic foot of water per hour.

A gallon of water (U. S. standard) weighs 8⅓ lbs., and contains 231 cubic inches.

A cubic foot of water weighs 62½ lbs., and contains 1,728 cubic inches, or 7½ gallons.

Circular apertures are most effective for discharging water, since they have less frictional surface for the same area.

Hydraulics treats of fluids in motion, and especially of water, the machinery and works for raising and conducting it, its action in canals, races and rivers, its adaptation to water wheels as prime movers, etc.

To find the velocity in feet per minute necessary to discharge a given volume of water in a given time, multiply the number of cubic feet of water by 144, and divide the product by the area of the pipe in inches.

To find the pressure in pounds per square inch of a column of water, multiply the height of the column in feet by .434. (Approximately every foot of elevation is considered equal to ½ lb. pressure per square inch.)

To find the diameter of a pump cylinder to move a given quantity of water per minute (100 feet of piston being the speed), divide the number of gallons by 4, then extract the square root, and the result will be the diameter in inches.

Vertical apertures, or slits on the side and running near to the bottom of vessels, issue the water with a mean velocity due at the sill or lower edge of opening, or with the velocity due to a point four-ninths of the whole height of head.

The time occupied in discharging equal quantities of water under equal heads, through pipes of equal lengths, will be different for varyings forms, and proportionally as follows: for a *straight line*, 90; for a *true curve*, 100; and for a *right angle*, 140.

To find the horse power necessary to elevate water to a given height, multiply the total weight of column of water in lbs. by the velocity per minute in feet, and divide the product by 33,000 (an allowance of 25 per cent. should be added for friction, etc.)

To find the area of a required pipe, the volume and velocity of water being given, multiply the number of cubic feet of water by 144, and divide the product by the velocity in feet per minute. The area being found, it is easy to get the diameter of pipe necessary.

To find the capacity of a cylinder in gallons. Multiplying the area in inches by the length of stroke in inches will give the total number of cubic inches: divide this amount by 231 (which is the cubical contents of a gallon in inches), and the product is the capacity in gallons.

The quantities of water discharged in equal times by the same apertures under different heads are nearly as the square roots of the corresponding heads, the heads being measured above the apertures.

The quantities of water discharged in the same time through different sized apertures, under different heads, are to one another in the compound ratio of areas of the apertures, and of the square roots of the heights of heads above the centers of the apertures.

The area of the steam piston, multiplied by the steam pressure, gives the total amount of pressure exerted. The area of the water piston, multiplied by the pressure of water per square inch, gives the resistance. A margin must be made between the power and the resistance to move the pistons at the required speed.

With thin plates on the bottom or sides of reservoir, the stream, issuing through circular openings, converges toward a point at about one-half its diameter from the outside of orifice, reducing the quantity discharged nearly five-eighths from the quantity that the velocity corresponding to the head should discharge.

With a horizontal cylindrical tube, the length and diameter being the same, the discharge will be the same as through a plain aperture. A horizontal cylindrical tube having greater length than diameter increases the discharge, and the discharge will continue to increase until the length reaches four times the diameter.

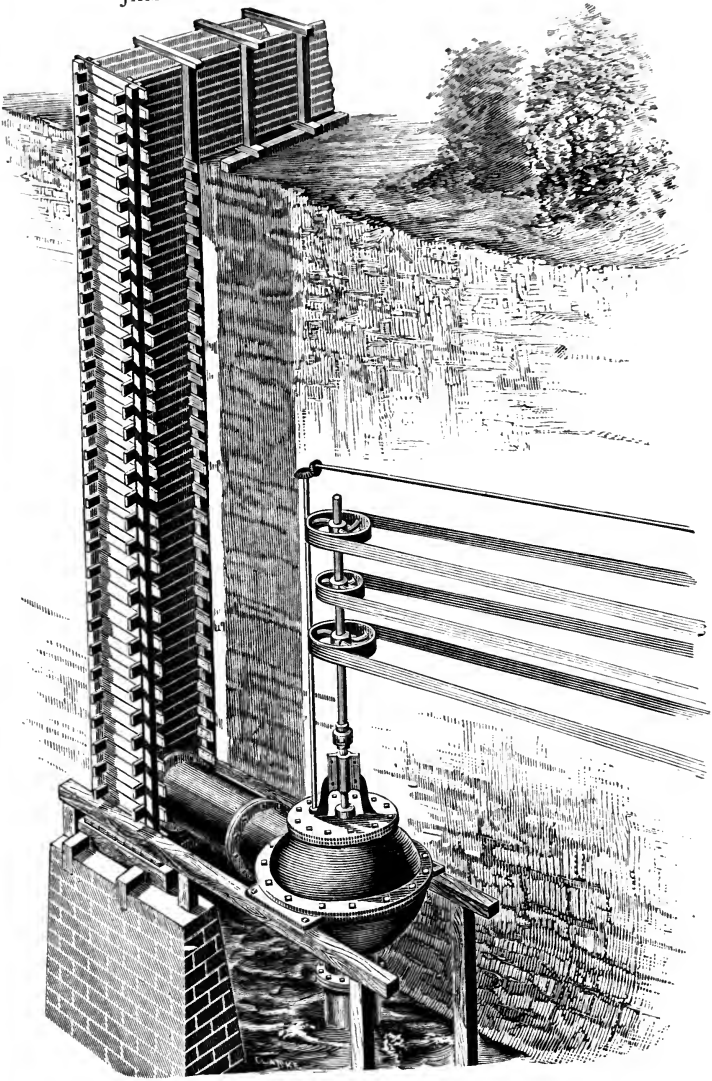
To find the quantity of water elevated in one minute running at 100 feet of piston per minute. Square the diameter of water cylinder in inches and multiply by 4. Example : The capacity of a 5-inch cylinder is desired. The square of the diameter (5 inches) is 25, which, multiplied by 4, gives 100, which is the number of gallons per minute (approximately.)

The best form of aperture for giving the greatest flow of water, is a conical aperture, whose greater base is the aperture, the height or length of the section of cone being half the diameter of aperture, and the area of the small opening to the area of the large opening as 10 to 16; there will be no contraction of the vein, and consequently the greatest attainable discharge will be the result.

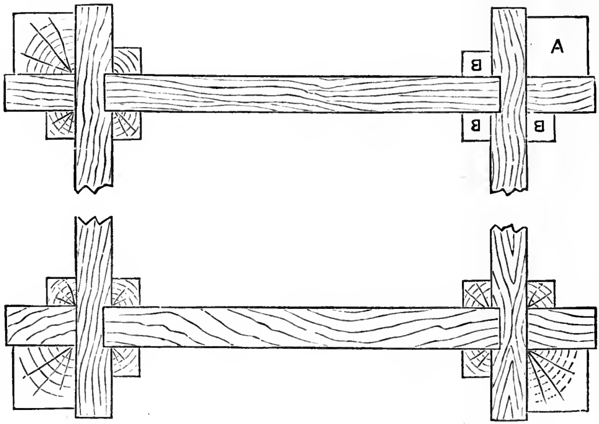
Water in falling is actuated by the same law as other falling bodies; passing through 1 foot in ¼ of a second, 4 feet in ½ second, 9 feet in ¾ of a second, and so on; hence its velocity flowing through an aperture in the side of a reservoir, bulkhead or any vessel, is the same as that of a heavy body falling freely from a height equal to the distance between the middle of the aperture or hole to the surface of water below.

Wooden Penstock for High Falls.

For the benefit of those who wish to adopt this plan for heads of 20 to 50 or 75 feet, we describe it fully. If well built, it is capable of withstanding even greater pressures or heads than those named. The corner posts A (see ground planter whieh) need in no case be over



by 6 inches square. For a head of 40 feet, with a penstock of the desired inside area to pass a sufficient quantity of water for our 26½ inch wheel, giving 110 horse power, the penstock would require to be 40 inches square in the clear, with a frame made to bolt the flange of the inlet pipe to the globe penstock. Then the plank for the first 15 feet would require to be 4 or 4½ inches thick; then for 15 feet further 3 inch plank would answer; the rest of the way 2 inch plank would be sufficient. The flume to pass the water into the penstock at the top would require to be the width of the upright part of penstock, and deep enough to pass the water 50 inches deep for a 26½ inch wheel. This would give a cross section to the inflowing water of 14 sectional feet, and pass the water at a speed of nearly 2 feet per second. Of course, a wheel of our make using less water than the 26½ inch wheel would not require so large a penstock.



Have the plank all gauged to a certain width, whatever they may be. If the penstock is to be 40 inches square inside, cut one-half the number of planks required 42 inches long. Gauge and size them down at each end to a size that they will all work. Then take the same number of planks and cut them 60 inches long; if the plank is four inches thick this will allow the plank to extend to the outside of posts on each side. They are then laid off evenly, 40 inches between gains, and gauged three inches from the face or outside of plank, which leaves a rabbet of 1 inch to receive the ends of the 42 inch plank. After all the planks are prepared, the 6 inch corner posts can be set up, and the work of putting up the plank commenced and carried up until the place is reached to splice the posts. These should be spliced and prepared previous to putting up, and are thus extended on up to the height

desired. The plank can and should be double-pinned or spiked at each end as the work progresses. After the plank are all on, the small corner strips marked (B B B in ground plan) should be well fitted in and nailed. If the work is well done the penstock need not leak a drop. The bottom can be planked with the same thickness of boards. A penstock 40 inches square inside, with 40 feet of water in it, would have a pressure of a little over 17½ pounds to the square inch, or 28,160 pounds total weight of water, besides the weight of penstock; therefore it will be well to put a good and solid foundation under it.

600 Bales Cotton; Believes Candidly it is the Best.

BARHAM, ANACHITA COUNTY, ARK., March 30th, 1885.

Mr. James Leffel, Springfield, Ohio:

DEAR SIR—I received yours of the 27, and in answer to the same would say that I am using one of your 26½ inch wheels bought last summer, one year ago, and it does all the work I expect it to do, it is running under 7 foot head, I have ginned two seasons with it and can gin 6 bales of cotton law gin every day on half gate, I also run a 30 inch bur and can grind 100 bushels of fine meal in 10 hours in the 2 seasons I gined 600 bales of cotton. I have been running the Brooks Wheel Mill, I purchased the Double Tnrbine from you and would say there is no comparison. I have been milling a long time and do believe candidly that the Leffel Wheel is the best water wheel made. Mine gives me perfect satisfaction, would have no other.

Very respectfully, WM. COX.

Guaranteed Good as the Leffel.

LAMDSTEN, March 30th, 1885.

Messrs. James Leffel & Co.:

I have been running the 30½ inch wheel that I got of you in August last, and it works well and gives entire satisfaction. We have about 10½ foot head over the wheel and with the gates ¾ open we run two pair of burs, four feet in diameter, one middling bur, one separator, one smutter, four sets of bolting reels,, four set of elevators, testing jack, &c., and make two barrels of flour per hour. This wheel displaced an 8½ foot overshoot wheel, and as far as I can judge, it will grind as much wheat per hour, and I think more with the same quautity of water and saves all the trouble of cutting of ice, and also stoppage with back water. I have had considerable experience with turbines in my mill during the last summer, as I was persuaded to try two other wheels, warranted to be equal, if not better than your wheel, and if they did not give good satisfaction to me the maker of the wheel was to pay all expenses of putting wheels in and damages besides. After a fair trial of the wheels I found that they were very dificent in power and did not render satisfaction by no means, consequently they was taken out, but I had to bear the trouble and expense, which was considerable. As far as I can judge there is no better wheel made than the Leffel.

JACOB WISTER.

Does all We Claim for it.

WEST MILTON, OHIO, April 4th, 1884.

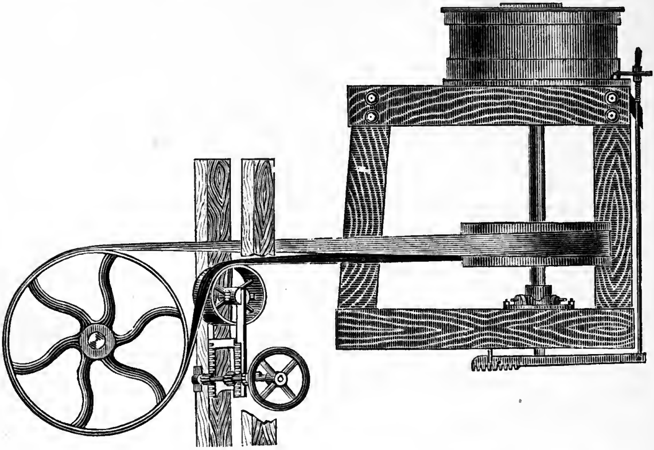
Messrs. James Leffel & Co.:

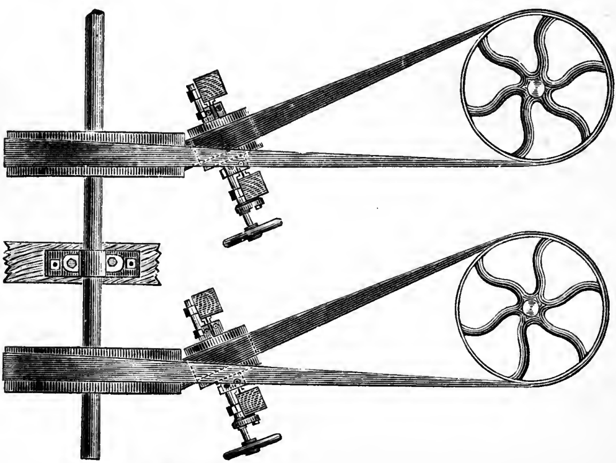
GENTLEMEN—It gives us pleasure to say we have now used your 10 inch wheel for several months under a 44 foot head in our flouring mill and are running one 3 foot burr, 2 set rolls, all the reels, elevators, conveyors, with smutter and purifier and find it gives us all the power necessary to finish up five bushels wheat per hour, and feel satisfied it will do all or more than you claimed for it. This wheel took the place of a "Little Giant" put in on trial.

Yours respectfully,

WEIMER & HOOVER.

Side View of Mill Stone Driven by Quarter-Turn Belt.





Down View of Mill Stones Driven by Quarter-Turn Belt.

Quarter-Turn Belt and Tightener.

The foregoing page contains two illustrations or views of a method now quite generally employed in driving mill stones, and frequently used in communicating the power to various other machinery. The cut at top of page gives a side view or elevation, showing one run of stone only, the others being located directly in a line with it are not seen. Any convenient number can be driven in that manner, it being only necessary to lengthen the horizontal shaft, on which the additional pulleys for each run of stone may be placed. It is to be understood that the horizontal shaft is driven direct from the upright water wheel shaft by a pair of bevel gears.

The cut on lower part of page represents a down view, or ground plan. It is supposed the person is looking downward and on top of the stones, when the horizontal shaft now appears as an upright one, and indeed the method is just as applicable with the driving shaft in an upright as a horizontal position. On page 65 we give such an arrangement, driving, however, a saw mill, and without the tightening pulley. It will be seen that almost any kind of machine having a vertical pulley may be run in that way.

The quarter-turn belt when used with the tightener or idle pulley requires a somewhat different arrangement or position of the pulleys doing the work, from that necessary without the idler. The precise position of these pulleys as related to each other, depends on the direction which the belt takes or the pulley runs, and also on which is the driving and receiving pulley. To make each position in each instance clear to one unaccustomed to their use, would require several diagrams and a full explanation. There may be as many as eight or ten positions, which would, however, include all from the simplest method as illustrated in saw mill cut, already mentioned, to the most complicated arrangement, wherein several idle and tightening pulleys are used. It is therefore necessary, usually, where this method is to be adopted, to advise with some one, or obtain the services of one acquainted with their use and application ; although it need not be difficult upon carefully considering the matter.

Driving Stone Polishing Mill at 2-3 Gate.

SIOUX FALLS, DAK., April 2d, 1885.

Messrs. James Leffel & Co., Springfield, Ohio:

GENTLEMEN—The two 48 inch Leffel Water Wheels, which the Drake Co. purchased from you to run their Stone Polishing Mill in this city continues to give us perfect satisfaction. In a usual way we run at ⅔ gate under a 13 foot heed, producing about 120 horse power, which we find sufficient for our present machinery. The Jasper and Granite stone which we handle is exceedingly rough on our machinery, but we have at no time experienced any difficulty with our motive power, and if at any future time another wheel should be necessary, our experience up to this time would certainly justify us in placing our order in your hands.

Yours respectfully, H. M. STEARNS,
Superintendent Drake Company.

Problems and Solutions.

PROBLEM I—To find the Circumference of a Circle, or of a Pulley:

SOLUTION.—Multiply the diameter by 3.1416; or as 7 is to 22 so is the diameter to the circumference.

PROBLEM 2.—To Compute the Diameter of a Circle, or of a Pulley:

SOLUTION—Divide the circumference by 3.1416; or multiply the circumference by .3183; or as 22 is to 7 so is the circumference to the diameter.

PROBLEM 3—To Compute the Area of a Circle:

SOLUTION.—Multiply the circumference by one-quarter of the diameter; or multiply the square of the diameter by .7854; or multiply the square of the circumference by .07958; or multiply half the circumference by half the diameter, or multiply the square of half the diameter by 3.1416.

PROBLEM 4—To find the Surface of a Sphere or Globe:

SOLUTION.—Multiply the diameter by the circumference; or multiply the square of the diam eter by 3.1416; or multiply 4 times the square of the radius by 3.1416.

PROBLEM 5—To Compute the Diameter of a Toothed Wheel:

SOLUTION.—Multiply the number of teeth by the number of *thirtyseconds* of an inch contained in the pitch, the product will be the diameter in inches and hundredths of an inch; or multiply the number of teeth by the true pitch and the product by .3184. These results give only the diameter between the pitch line on one side and the same line on the other side, and not the entire diameter from *point* to *point* of teeth on opposite sides. It must also be borne in mind that these results are only approximate diameters, since the wheel often varies from the computed diameter in consequence of shrinkage and other causes.

PROBLEM 6—To Compute the Number of Teeth in Pinion to have any Given Velocity:

SOLUTION.—Multiply the velocity or number of revolutions of the driver by its number of teeth or its diameter, and divide the preduct by the desired number of revolutions of the pinion or driven.

PROBLEM 7—To Compute the Diameter of a Pinion, when the Diameter of the Driver, and the number of Teeth in Driver and Pinion are given:

SOLUTION.—Multiply the diameter of driver by the number of teeth in the pinion and divide the product by the number of teeth in the driver, and the quotient will be the diameter of pinion.

PROBLEM 8—*To Compute the Number of Revolutions of a Pinion or Driven, when the Number of Revolutions of Driver, and the Diameter or the Number of Teeth of Driver and Driven are given:*

SOLUTION.—Multiply the number of revolutions of driver by its number of teeth or its diameter, and divide the product by the number of teeth or the diameter of the driven.

PROBLEM 9—*To ascertain the Number of Revolutions of a Driver, when the Revolutions of Driven and Teeth or Diameter of Driver and Driven are Given:*

SOLUTION.—Multiply the number of teeth or the diameter of driven by its revolutions and divide the product by the number of teeth or the diameter of driver.

PROBLEM 10—*To Ascertain the Number of Revolutions of the last wheel at the End of a Train of Spur Wheels, all of which are in a line and mesh into one another, when the Revolutions of the first Wheel and the Number of Teeth or the Diameter of the First and Last are given:*

SOLUTION.—Multiply the revolutions of the first wheel by its number of teeth or its diameter, and divide the product by the number of teeth or the diameter of the last wheel; the result is its number of revolutions.

PROBLEM 11—*To Ascertain the Number of Teeth in each Wheel for a Train of Spur Wheels, each to have a given Velocity:*

SOLUTION.—Multiply the number of revolutions of the driving wheel by its number of teeth, and divide the product by the number of revolutions each wheel is to make, to ascertain the number of teeth required for each.

PROBLEM 12—*To Compute the Number of Revolutions of the Last Wheel in a Train of Wheels and Pinions, Spurs or Bevels, when the Revolutions of the First or Driver, and the Diameter, the Teeth or the Circumference of all the Drivers and Pinions are given:*

SOLUTION.—Multiply the diameter, the circumference, or the number of teeth of all the driving wheels together, and this continued product by the number of revolutions of the first wheel, and divide this product by the continued product of the diameter, the circumference, or the number of teeth of all the pinions, and the quotient will be the number of revolutions of the last wheel. EXAMPLE: if the diameters, the circumferences, or the number of teeth of a train of wheels are 8, 8, 10, 12 and 6, and the diameters, circumferences, or number of teeth of the pinions are 4, 5, 5, 5 and 6, and the driver has ten revolutions,

what will be the number of revolutions for the last pinion? Multiply all the drivers together and then by 10 revolutions and you have 8 by 8 by 10 by 12 by 6 by 10 equal to 460800; divide this amount by the product of the figures for pinions, 4 by 5 by 5 by 5 by 6 equal to 3000, and the quotient will be 153 or the number of revolutions of last wheel. This rule is equally applicable to a train of pulleys, the given elements being the diameter and the circumference.

PROBLEM 13—To find the number of Revolutions of Driven Pulley, the Revolutions of Driver, and Diameter of Driver and Driven being given:

SOLUTION.—Multiply the revolutions of driver by its diameter, and divide the product by the diameter of driven.

PROBLEM 14—To compute the Diameter of Driven Pulley for any desired Number of Revolutions, the Size and Velocity of Driver being known.

SOLUTION.—Multiply the velocity of driver by its diameter, and divide the product by the number of revolutions it is desired the driven shall make.

PROBLEM 15—To Ascertain the Diameter of Driving Pulley:

SOLUTION.—Multiply the diameter of driven by the number of revolutions you desire it shall make, and divide the product by the number of revolutions of the driver.

Mining Wheel in Circular Saw Mill.

MORONI, SNAPETE COUNTY, UTAH, February 9th, 1881.

James Leffel & Co., Springfield, Ohio.

GENTS—We take pleasure in stating that the 13¼ inch Vertical Double Turbine Water Wheel purchased of your firm last season, through your agent here, Mr. C. Kemp, and set to work as per his directions, gives us every satisfaction. We have a penstock 60 feet high, built on plan as described on page 79 of your illustrated pamphlet of 1880, of 4 inch red pine plank, lined with inch timber, globe bolted to bottom of penstock and run direct to circular saw pulley with open belt, as shown on page 37 of pamphlet for 1880; diameter pulley on water wheel shaft 18 inches; Mandrel pulley, 22 inches. We have a Cooper rotary mill, 52 inch Desston saw, and can cut from 5,000 to 7,000 feet of inch lumber per day of 12 hours. Other parties put in a new steam saw mill last year just above us—same kind of mill, running with same size saw (52 inch,) but we can sail right through a tough log that will bring their engine, a 22 horse power Ames, to a dead halt, although carrying heavy pressure.

JENS C. NELSEN.

All They are Represented.

APPLETON, WIS., April 1st, 1885.

James Leffel & Co., Springfield, Ohio:

GENTLEMEN—The 40, 61 and 66 inch Water Wheel which we purchased of your agents, Messrs, Okeef & Sons, of this city, on the 19th of April, 1883, for the use of our Ravine Paper Mills, are giving us entire satisfaction, and are all they are represented to be,

S. K. WAMBOLD,
Mang. and Treas. Fox River Flour & Paper Co.

1-3 to 1-2 Gate, Night and Day.

TECUMSEH, MICH., April 4, 1885.

Messrs. James Leffel & Co., Springfield, O.:

GENTLEMEN—We are using one of your 40 inch Special Wheels. Wheel has been in operation day and night for nearly two years and has never given us five minutes' trouble since starting. Our head varies from 16 to 18 feet. We never use more than ½ gate, seldom more than ⅓. We draw 1 separator, 1 pair 30 inch smooth rolls, 2 large size brush scourers, 2 large bran dusters, 6 purifiers, 8 stands of elevators, 6 reels and 1 centrifugal. Wheel has only a 2 foot pit below it, which we consider only about one-half what it should have. We consider your wheel, for all places and all kinds of work, without an equal. Yours truly, WM. HAYDEN,
per Wilson.

Thirty Years' Experience of a Large Powder Company.

CLEVELAND, O., February 14th, 1883.

Messrs. James Leffel & Co., Springfield, O.:

GENTS—Our experience with your Leffel Improved Double Turbine Water Wheel has been highly satisfactory. In March, 1873, we put in two 35 inch Wheels, displacing a four foot Reynolds Wheel, deriving therefrom full as great power, and a most decided saving of water. March, 1875, we put in one 35 inch wheel, displacing a Stout, Mills & Temple American Turbine. These Leffels run with no loss of efficiency or increased consumption of water that we can perceive, either at full or part gate, and with a decided advantage over the Stout, Mills & Temple in the attention required to prevent clogging of the wheel. We also, at the same time, put a 26½ in. wheel in a new mill, which worked satisfactorily. Since then we have put in two 30½ inch wheels, and shall, as soon as we get time, put in still another of the same pattern. In an extensive experience with water wheels of over thirty years, we can safely say that yours is the best water wheel we have yet tried.

Yours truly, AUSTIN POWDER CO.,
L. Austin, President.

Mining Wheel 182 Ft. Head.

DAHLONEGA, GA., Nov. 1st, 1883.

Capt. Frank W. Hall, Dahlonega, Ga.:

DEAR SIR—It gives me pleasure to say that the 13¼ inch Leffel Wheel, which you put in for me at the "Ivey Mill," is doing its work well and giving entire satisfaction. I find with the small amount of 60 inches water under the pressure of 182 feet, that the wheel gives ample power to drive the 60 stamps of 450 lbs each, and I think surplus power to drive 20 or 30 additional stamps. The wheel is the most complete power I have ever seen or used, and a success in every way. To those who wish to gain the greatest amount of power from the smallest possible supply of water, I would cheerfully recommend the Leffel Wheel, knowing there will be satisfaction in every instance. With respect I am, Yours truly.

J. P. IMBODEN, Supt. of Mines.

Ten Inch Leffel Cutting 6000 Feet Lumber.

DEER LODGE, MONTANA, April 6, 1885.

James Leffel & Co.:

DEAR SIRS—For two summers last past I have been running a 50 inch saw in the toughest of red fir, with one of your 10 inch turbine wheels, using about 175 inches of water, (miner's measurement, the method in universal use in mining countries) under 75 foot pressure. It has done the required work satisfactorily, and is well capable of cutting 6,000 feet per day in fair size logs. Usually run with gates full open, though it seems to give about the same power with gates about ¾ open. I believe these wheels will, properly managed, do about what is claimed for them.

Very respectfully yours, J. C. ROBINSON.

Circular Saw Mill with Quarter-Turn Belt.

The illustration on following page gives a plan somewhat in detail of a very simple and efficient method for arranging circular mills in many instances. This style when adopted, if well put up, with proper size of pulleys, and suitable length of belt, cannot fail to give good satisfaction. Usually in building mills upon this plan, a wheel of comparatively small size is used, operating under a head of considerable height. In the cut, the wheel is shown in our Patent Globe, to which a head pipe is attached, leading from the ordinary upright wooden penstock. The pipe being attached to the bulkhead on outside of mill, passes through the stone wall, and connects directly to the globe ; this latter having, as is shown, a substantial foundation of heavy timbers, and stone piers or masonry. To the sides of the globe casing are flanges to rest upon the sills, affording it a convenient and solid support. A short draft tube is seen attached to lower part of cylinder below, which of course is not necessary in all instances, since the wheel and globe can frequently be placed at the bottom of head, as may be seen in other parts of pamphlet.

The power is transmitted directly to pulley on saw mandrel, by means of what is usually termed a quarter-turn belt, from a pulley placed on the water wheel shaft. One entirely unacquainted with the arrangement of the pulleys and belts in this manner, should obtain the services or advice of some one who has had some experience in arranging, applying and putting such belts into operation.

It will be observed that the centre of horizontal pulley on water wheel shaft is placed very nearly on a level with the bottom of pulley on saw mandrel, and the centre of pulley on mandrel is almost in a line with the further edge of the pulley on water wheel shaft, although it may not be observed from the illustration.

The arrows indicate the only direction the belt can run, with this particular situation of pulleys in relation to each other. Should the direction of belt be changed, then an entire change of the location of pulleys would become necessary. There need, however, be no difficulty in the matter, upon due consideration.

When this method of using the Leffel Wheel is adopted, it is best to have the pulleys situated some distance apart, perhaps 12 to 18 feet, and not too large in dimensions, nor should the one be very large and the other very small. When it can be so arranged, they may be as nearly the same size as the proper speeds of the water wheel and saw will admit. In almost all cases, however, the pulley on wheel shaft will be smallest, since the method is best applied to high heads and small wheels. We will give full information on any point concerning the method when desired.

In ordering wheels state whether they must run WITH or AGAINST sun, that is Right or Left hand.

Es sind über 11,000 Leffel Räder im Gebrauch, welche über 500,000 Pferdekraft haben.

Obwohl wir die Thatsache, daß unsere Räder allgemeine Zufriedenheit geben unter den verschiedensten Umständen, welchen sie unterworfen sind, als einen unumstößlichen Beweis ihrer Superiorität über Andere halten, so muß dennoch den ungeheure Anzahl, welche wir verkauft haben, als noch viel stärkerer Beweis ihrer großen Verdienste gelten und gibt unzweifelhaft Zeugniß, daß sie die Bedürfnissen der Fabrikanten, welche auf eine Wasserkraft angewiesen sind, vollkommen entsprechen. So groß war der Beifall, den sie fanden und so groß war die Nachfrage nach denselben, daß wir jetzt Elf Tausend Räder, welche die ungeheure Kraft von fünf Hundert Tausend Pferdekraft ergeben, in erfolgreicher Operation haben. Wir glauben, daß kein anderer Beweis als dieser nothwendig ist, um irgend eine vorurtheilsfreie Person von den unvergleichlichen Vorzügen unseres Rades zu überzeugen.

Ueber 3000 günstige Beurtheilungen über das Leffel Rades.

Wir geben in dieser Auflage einige Briefe von den vielen, welche wir von Solchen im Besitze haben, die unser Wasserrad gebrauchen. Wenn es der Raum und die Geduld der Leser erlauben würde, würden wir mit Vergnügen noch mehrere publiziren, aber ein Buch von der dreifachen Größe des gegenwärtigen, selbst wenn sonst gar nichts darin enthalten, nothwendig wäre, um allen den Empfehlungsbriefen, die wir im Besitze haben, Aufnahme zu gewähren, da wir in unserer Office 3000 Briefe ähnlichen Inhaltes, wie die in diesem Buche produzirten, aufzuweisen haben. Wir hoffen, daß diese Entschuldigung von unseren zahlreichen Freunden, die uns mit diesen geschätzten Briefen beehrten, die aber wegen Mangel an Raum nicht Aufnahme finden konnten, als hinreichend erachtet werden wird und danken wir Allen, für die ausgesprochene gute Meinung und der unbegrenzten Patronage, die sie unseren Rädern zu Theil werden ließen.

Es hat Viele in Erstaunen gesetzt.

Pierce City, Mo., den 31. Dezember 1882.

James Leffel & Co.:

Werthe Herren! Ihren Brief vom 28. Dezember erhalten. Als Antwort diene Ihnen Folgendes: Das 20zollige Special-Rad, das ich von Ihnen gekauft habe, hat schon manchen Mann zum Kopfschütteln gebracht. Ich habe dasselbe jetzt 14 Monate im beständigen Betriebe und kann meine Zufriedenheit damit nicht genug aussprechen, denn das kleine eiserne Pferd arbeitet, ob das Wasser hell oder trübe ist, das heißt, ob Blätter oder Stöcke darin fließen oder nicht, ob Stauwasser vorhanden, oder nicht. Es bestand eine Probe, welche alle Anwesenden in Staunen versetzte. Es blieb nemlich auf einmal, als es im vollen Laufe war, plötzlich stehen, so daß der große Riemen absprang. Was ist los? hieß es überall. Das Rad muß sicherlich zerbrochen sein, war die allgemeine Ansicht. Ich aber ließ das Wasser abwenden und fand das Rad so dicht verschlossen, daß man nicht ein Haar hätte durchziehen können. Ich wollte es öffnen, aber auch das ging nicht. Ich löste deshalb die Riemen von den Gates los und fand einen Streifen $1\frac{1}{4}$x2 Zoll, 2 Fuß

lang um das Rad herum liegen und glaubten jetzt alle Anwesenden, daß das Rad zerbrochen sein müßte. Als ich aber 5 Gates herausnahm und den Strick los bekam, setzte ich das Rad wieder zusammen und dasselbe arbeitete gerade so gut, wie zuvor. Allen Verlust, den ich hatte, war 1½ Stunde Zeit. Welches Rad mit Register würde eine solche Probe aushalten? Das Rad treibt eine 50zollige Zirkelsäge und einen Edger unter 8 Fuß Fall und schneidet 2000—2500 Fuß Eichenholz. Bei weniger als 10 Fuß ist nur ¾ Gate erforderlich. Unsere Logs haben 999 Knorren, denn groberes Holz, wie es hier gibt, habe ich noch nirgends gesehen, und wenn dieses Jemand bezweifelt, so soll er nur nach meiner Mühle kommen und es mit eignen Augen sehen.

Jeder, der ein Wasserrad gebraucht, kann kein besseres, als das Leffel'sche bekommen, er mag es kaufen, wo er will, denn ich habe schon viele Sorten Räder eingesetzt, aber noch nie eines mit demselben Erfolg. Ich habe bereits 13 Räder nach dem Leffel'schen Patent eingesetzt und nächsten Sommer werde ich wieder ein 11½ und ein 19½ zolliges in meiner Mahlmühle anbringen.

Achtungsvoll, John Elbert.

Eine 33jährige Erfahrung mit Wasserräder.

Monmouth, Jl., den 21 Januar 1883.

James Leffel & Co.:

Geehrte Herren! Ich fühle mich verpflichtet, Ihnen über die Leistungen des Wasserrades, das ich von Ihnen den 22. September erhalten habe, Nachricht zu geben. Am 1. Oktober setzte ich ein 26½ Zoll Leffel-Wasserrad zur Arbeit zurecht. Seit dieser Zeit treibt es mir zwei Gänge, einen für Waizen und einen für Korn, sowie die andere Maschinerie, die zur Verfertigung des Mehles nothwendig ist, d. h. einen Waizenseperator, eine smut-Maschine, einen Purifier und einen zwei Pferde Kraft Kornscheller. Der Waizenstein ist vier Fuß, er mahlt sechs Buschel Waizen per Stunde. Der Kornstein ist ebenfalls 4 Fuß. Er mahlt acht Buschel Korn oder zwanzig Buschel chopp per Stunde und das kleine Rad setzt alles dieses zur erforderlichen Schnelligkeit in Bewegung, nur mit der halbgeöffneten Gate unter vier Fuß Fall. Ich treibe das Mahl-Geschäft seit 33 Jahren, 7 Jahre in Europa und die übrige Zeit in diesem Lande. Ich habe in dieser Zeit mit verschiedenen Wasserrädern gearbeitet, Unterschlächtige, Ueberschlächtige, Brusträder, Turbinen u. s. w., jedoch von allen diesen besitzt keines die Kraft, wie das James Leffel Wasserrad, soviel Mühlwerk mit so wenig Wasserkraft in die erforderliche Bewegung zu setzen. Ich bedaure nur, mich nicht schon früher dieses J. Leffel Wasserrad bedient zu haben und kann ich jedem Fabrikanten oder Miller, der sein Geschäft durch Wasser treibt, dieses J. Leffel Wasserrad auf's Beste empfehlen, denn diese Gate die an diesem Rade ist, kann gar nicht geboten werden. Achtungsvollst bin ich Ihr Freund,

Peter Oswald.

N. B. — Noch muß ich bemerken, daß ich ein Eclipse-Rad gebraucht habe in den letzten drei Jahren und konnte mit der gleichen Wasserkraft nur vier Buschel Waizen mahlen per Stunde. Das ist das beste was ich thun konnte. Zwei Steine konnte das Eclipse-Rad gar nicht treiben. Es hat die Hälfte Kraft nicht, die das J. Leffel Wasserrad besitzt.

Die beste in Amerika.

Maysvillle, Wisc., den 18. Februar 1883.

James Leffel & Co.:

Werthe Herren! Ich brauche seit 13 Jahren fünf von Ihren verbesserten doppelten Wasser-Turbinen, von verschiedenen Größen, 35, 30, 26 und zwei 23 Zoll Turbinen. Die 35zöllige Turbine treibt eine Circulrr-Säge 54 Zoll Durchmesser und sägt in 10 Stunden bis 8000 Fuß hartes Lumber unter 12 Fuß Fall Die 30zollige treibt zwei Paar 4 Fuß Mahlsteine und alle andere Maschinerie in der Mühle, ausgenommen die Reinigungs-Maschinen. Die 26zollige Turbine treibt vier doppelte Walzen-Stühle, fabrizirt bei E. P. Allis & Co. Die 23zollige Turbine treibt die Reinigungs-Maschinen und die zugehörigen Elevators. Die andere 23zollige Turbine treibt den Futterstein. Alle Turbinen laufen unter 13 Fuß Fall. Die Mühle macht bei der jetzigen Einrichtung unter vollen Fall, vier Faß Mehl per Stunde fertig und 25 Buschel Schrot. Alle Turbinen, seit sie in beiden Mühlen plazirt sind, haben noch nicht mehr als zehn Dollars Reparatur gekostet. Ich bin der vollen Ansicht, daß die Leffel Turbine die beste in Amerika ist, in Bezug auf Kraft bei halber oder voller Oeffnung, und würde Jedermann rathen, der eine Turbine braucht, keine andere als nur die Leffel Turbine zu kaufen.

Achtungsvoll, F. Paustian.

Lauft nach 11 Jahren noch so gut als je.

Cedarburg, Wisc., den 27. Januar 1883.

James Leffel & Co.:

Geehrte Herren! Ihr 48 Zoll Rad, welches wir im Juni 1872 kauften, treibt unsre Mühle noch wie früher mit sechs Paar Steinen und Maschinerie auf 12 Fuß Fall. Jetzt ist die Mühle mit Walzen eingerichtet und dieselben scheinen nicht so viel Kraft nöthig zu haben, als Steine. Wir haben blos das eine Rad um Alles zu treiben, was sich in die Mühle befindet.

Freudlichst grüßt, A. Bodendoerfer.

York, Nebr., den 14. April 1885.

James Leffel & Co.:

Werthe Herren! Ihren Brief erhalten und diene zur Antwort, daß das 23zollige Wasserrad, welches ich im Juli 1884 von Ihnen kaufte, unter 8 Fuß Fall läuft und bei $\frac{1}{3}$ geöffneter Gate einen 3 Fuß Stein treibt, welcher 3 Buschel Weizen per Stunde mahlt, sowie die anderen erforderlichen Maschinen zum Verfertigen des Mehles Ich habe früher mit einem Oversoht gemahlen, aber der Ihrige gefällt mir besser, weil er unter demselben Fall und selbigem Strom noch einmal soviel Kraft hat. Das Rad läßt nichts zu wünschen übrig. Achtungsvoll, Franz Wiens.

Unser neues Fabrikgebäude ist groß und bequem, indem es besonders für diesen Zweck gebaut wurde. Die gebrauchten Werkzeuge wurden ebenfalls mit großer Sorgfalt ausgewählt, so daß wir sie schnell und gut herstellen können.

Bei der Karte in einem anderen Theile dieses Pamphletes und der Abbildung unserer Fabrik kann man ersehen, daß unsere Versendungs-Facilitäten ausgezeichnet sind, da vor unserer Thüre mehrere Eisenbahnen sind, die nach jedem Theile der Welt gehen.

They Said it Would Fail.

LEDFORD'S MILLS, TULLAHOMA, TENN, April 4th, 1885.

James Leffel & Co.:

GENTLEMEN—The 11½ Turbine Water Wheel I bought of you last August is giving perfect satisfaction. It is operating under 30 foot head. Runs two pair of burs successfully, one a 4 foot, the other 3½ foot, at full gate. I was told by many that it would prove a failure. That I did not have water sufficient to run a Turbine, as there was a Turbine put in from some other company previous to my buying the property, which proved a failure. It is in every respect superior to the overshot it displaced.

Yours truly, S. V. LEDFORD.

125 bbl Roller Mill.

ROCHESTER, N. Y., March 30th, 1885.

Messrs. James Leffel & Co.:

GENTS—The thirty-five inch Water Wheel, special, from you gives us entire satisfaction We are driving a 125 barrel roller mill and it does its work splendidly under a 60 foot fall. Yours respectfully,

GERLING BROTHERS.

Grinds With One-Half Gate.

Messrs. James Leffel & Co.:

SIRS—We are using a thirty-six inch "Leffel's Improved Double Turbine Water Wheel," and can say that it gives entire satisfaction, running a wheat and corn mill with all the machinery requisite for the same, with only half gate water.

Yours, &c., REGEN BROTHERS.

VERONA, MARSHALL COUNTY, TENN.

175 Barrel Mill With 3-5 Gate.

BOARDMAN, WIS., March 30, 1885.

James Leffel & Co., Springfield, O.:

GENTS—The 48 inch Water Wheel purchased of you last fall has proved satisfactory in every respect. We took out a 60 inch Stout Mills & Temple Wheel and put your 48 inch in its place and started up under 16 foot head. Our mill has capacity of 175 barrels flour daily. When we were making the change some of the boys in the mill thought the 48 inch would not start the mill, it looked so small beside the one taken out, but when we come to let the water on they found it would carry the mill with about 3-5 gate under 16 foot head. Yours truly,

JOHNSTON. BRO. & CO.,
Successors to W. & Jos. Johnston

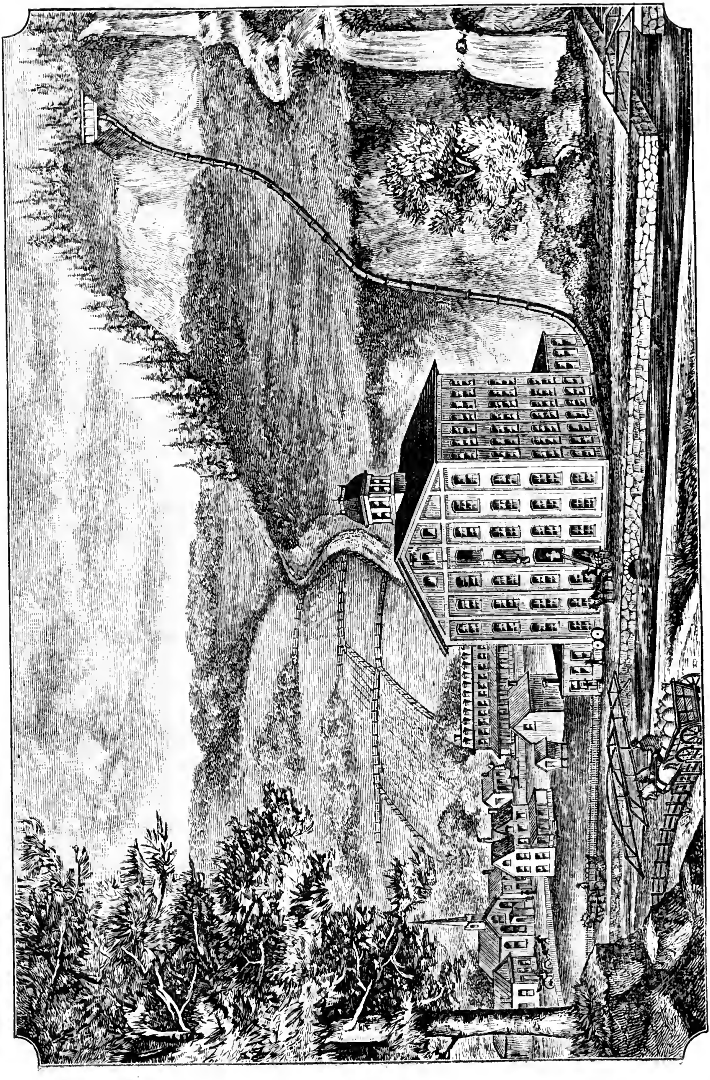
Displaced 52 Feet Overshot and 8 Feet Breast Wheel. Gold and Silver Mill.

DAYTON, NEV., Feb. 5th, 1883.

Messrs. James Leffel & Co.:

DEAR SIRS—Yours of December 17th, directed to Lyon M. & M. Co., at hand, and as that Company is out of existence, I have taken the liberty to answer it myself, for the reason that before Lyon Mill ordered a wheel, I had the choice of a wheel for the Company, and I chose your wheel. I think you made the wheel late in 1875 or early in '76. I put in the wheel; you also made case for it. It has been in constant use ever since, and the water at times quite muddy from tailings run into the river from mills above. Considering the water we use for power, I don't believe there was ever a piece of machinery put together that gave more perfect satisfaction than your wheel.

Lyon Mill Co. bought another of your wheels last year and we have it now; but the way the old wheel is operating it may be years yet before it will be worn out; there is never any repairs on it. I have run that wheel over 100 days without stop-



ping, and did not stop then for the wheel, but to clean out the boiler in the mill. If I had use for *one hundred wheels* they would all be Leffel's Wheels, as then I could depend on my power. Ours is a 35 inch; we don't use more than ⅓ gate; the wheel is very economical as your gates are the most perfect form; we adjust them for the water we have as perfectly as you can an engine by its throttle. Ours is a quartz or tailings mill, about 160 tons per 24 hours. We have 12 pans and 12 settlers, which take from 12 to 14 horse power to the pan, making fully 150 horse power besides our Battery of ten stamps and two mills for crushing rock. The same 24 inch main driving belt is on that I put on when I put in the wheel seven years ago, so you can judge that it does its work very easily. The belt travels 43 feet per second, the driving pulley 4 feet 4 inches, driven pulley 11 feet.

Our wheel lays on its side, but I am willing to bet and give large odds, that it will run *upright, on its side, on an angle,* or *inclined,* or any way that it can be set up, and give good satisfaction. There is never any trouble with the wheel. We have 56 feet head of water, run with gates ⅓ open; your wheel is driving the machinery that a 52 foot overshot and an 8 foot breast wheel formerly did; at the same time we are not getting half of the power in your wheel that it contains, on account of not having the water to fill it; but it will do the work economically according to the water, much or little. Wishing you success, allow me to subscribe myself, Truly yours,

CHARLES H. RULISON, Supt. for J. M. Douglass & Co.,
Successors to Lyon Mill & Mining Co

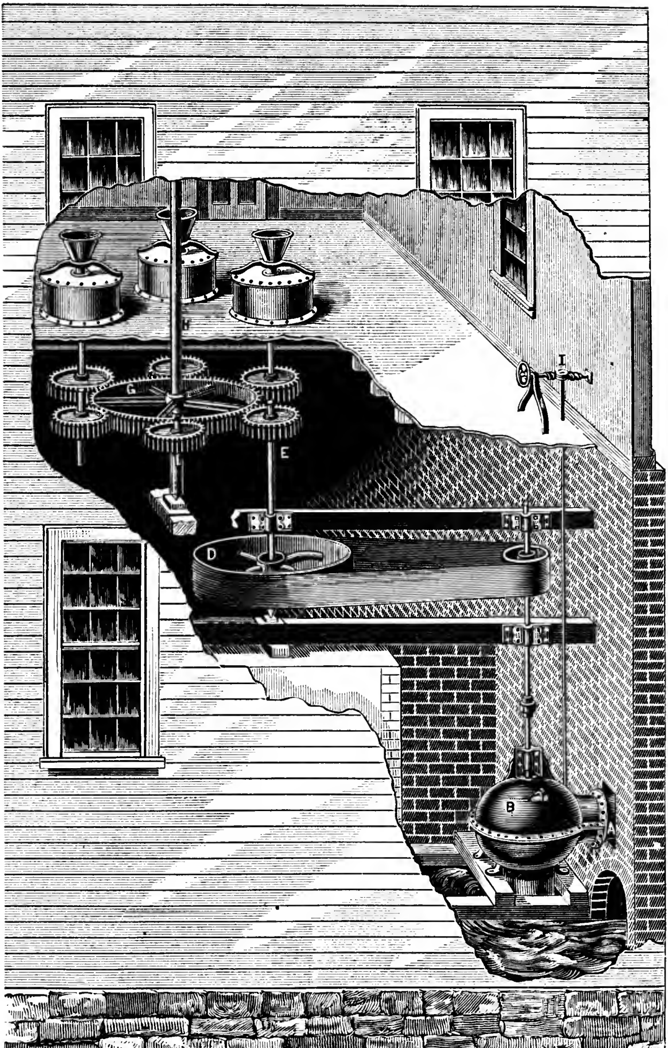
High Falls and Small Quantities of Water.

A PROPER TEST FOR A TURBINE WHEEL.

The severest practical tests to which turbines can be subjected, are to take the place of overshot wheels under high falls, and when applied to heads and pressures entirely too great to admit at all of the application of an overshot either single or double; and in both instances where the quantity of water is extremely limited, being only supplied by a few springs. It can certainly be claimed for the wheel that succeeds under those circumstances, that it is a strong and durable one, easy of application and management when in operation; and that it is the very best turbine that can be constructed.

We therefore invite special attention to the statements we publish elsewhere in this pamphlet from practical millers and millwrights, who have had years of experience with overshot wheels, under high falls and small quantities of water—just the circumstances under which it has been formerly considered impossible for any turbine to successfully compete with an overshot; and we think it not too much to say, that the Leffel Wheel is the *only wheel* that can achieve such results under such conditions. But severe as is this test, the Leffel Wheel has not only proven equal but superior in every respect to the overshot; and it will also be observed that, notwithstanding the high degree of economy demanded in the use of so small a quantity of water, *not one of the wheels is using full-drawn gates. In fact, some are operating with gates only one-quarter open;* thus proving beyond a doubt the highest degree of economy in our wheel with partial gates.

Another fact that cannot escape attention, is the immense power produced by such small wheels. We claim this as a feature peculiar to the Leffel Wheel; and from the principle of its construction, we are able yet to increase its capacity much beyond its present power, if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in any case the circumstances may seem to require it. We have found, by careful comparison with many other wheels, that we can produce a far greater power from the same size wheel, thus enabling us to use a much smaller wheel for any purpose than is usually applied by any other form of turbine.

We built, some time since, a wheel of but 10 inches in diameter, and using the same number of square inches and cubic feet of water that our 7⅝ inch wheel uses; it supersedes a 120 horse power engine, as the wheel gives that power and has a head of 228 feet. It was built of fine brass and steel, with buckets made of German Silver, and was a perfect model of strength and beauty. We have also put in operation a number of others, under heads of 80 feet and over. One was built and applied recently to a head of 300 feet, for mining purposes, being the highest head ever utilized in this country. In fact, the form of its construction, and the nature of the action of the water upon it, admits of its use under pressures far greater even than those mentioned.

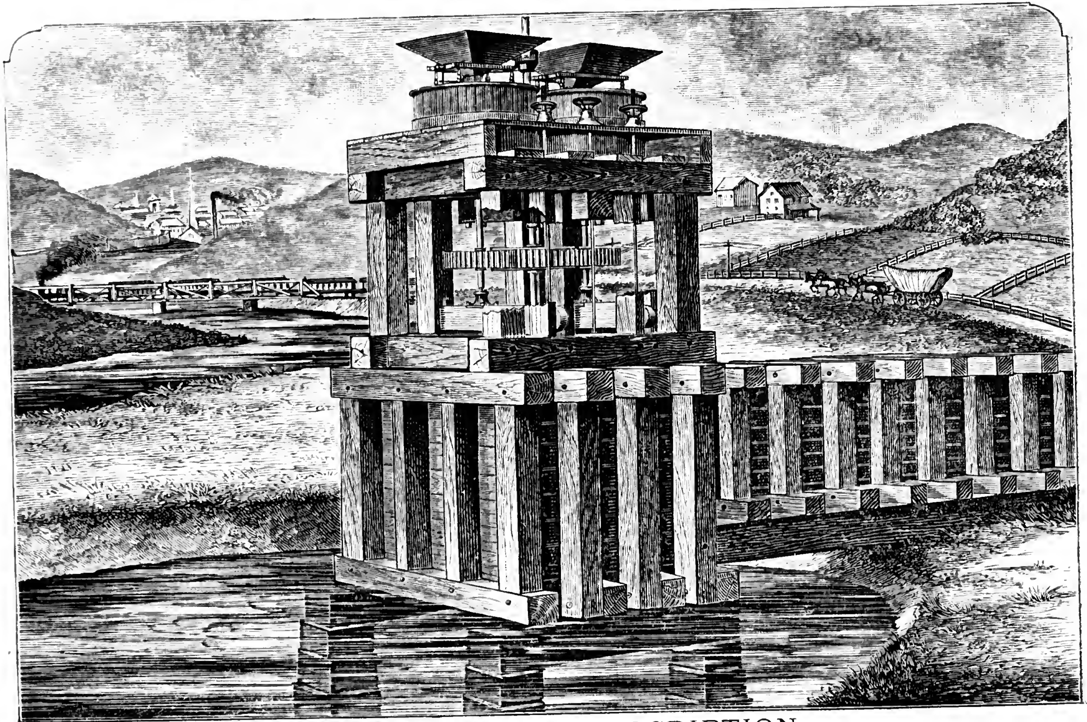
The essential points to be observed are few and simple, and consist mainly in having the machinery immediately connected to the wheel of neat proportions, and as light as is consistent with the work to be performed, and otherwise to reduce the friction to the smallest amount, as it must be obvious that massive machinery and much friction upon a small wheel running at a high velocity must seriously detract from the good performance of the wheel. Simplicity in the arrangement of machinery is likewise of the greatest importance, for it is a very easy matter to so absorb the power of small wheels by undue length of shafting and long trains of gearing, particularly *bevel* gearing, that there will be but comparatively little available power left.

Description of Plates on Pages 70 and 72.

The plates on pages 70 and 72 illustrate one of the most complete and successful achievements of hydraulic engineering in this country, which at once shows that, by the use of the Leffel Wheel, many valuable powers can be created, where now it is considered impracticable by reason of the high fall and limited amount of water in the stream. The success of this will not only establish the fact that the Leffel Wheel is durable and gives a steady motion under excessively high falls, but, also, that so great is its economy in use of water that a surprisingly large amount of power can be obtained from a very small stream of water. In fact the amount of work done by the Leffel Wheel under these high falls, when compared with the small stream of water used, is surprising and a mystery to those who are not sufficiently acquainted with the principles governing the operation of the Wheel to know that it embraces the elements requisite to give the very largest amount of power that is possible to obtain from a limited quantity ot water. We, therefore, call particular attention to this mill, as it will no doubt, convince others that they, by the use of the Leffel Wheel, may secure equally as valuable and constant a power. This mill, as

shown, is a large flouring mill belonging to H. C. Williams, Ithica, N. Y., and has five to six run of large burrs, with all the necessary machinery for a first-class merchant mill. On page 72 will be found plate and detailed description of the machinery, as arranged in the mill. The mill is located at the base of a hill, from the summit of which the water is obtained to drive it. The stream is a very small one indeed, furnishing but a limited quantity of water. The water is carried down to the Wheel (which is located in basement of mill) through an iron pipe 500 feet long, where it is attached to a Globe case in which the Wheel is placed. The Wheel itself is 15¼ inches diameter, but is reduced in capacity, so that it uses, with full gate, only the same quantity of water as our 11½ inch Wheel, and can, therefore, virtually be regarded as one of that size. It is made wholly of brass and steel, and of the highest finish. The fall employed is 95 feet, and although the Wheel with full gates uses only 14 square inches of water, yet it gives sufficient power to run six large burrs at one time, besides a vast amount of other machinery, such as separator, packer, etc. About 200 feet from lower end of main pipe is attached a branch pipe leading down to another mill, (plaster mill,) in which is placed a 13½ inch Wheel, reduced in capacity to a 10-inch Wheel; this Wheel operates under 82 feet fall, and is enclosed in Globe case similar to the one in flour mill. The plaster mill is not shown in the plate. After the water has operated upon the Wheel, it is conducted through an underground tunnel and discharges through the small archway into the channel of a large stream which will be seen flowing in front of the mill. The operation of this Wheel has excited the greatest interest and wonder throughout that vicinity.

The plate on page 72 gives in detail the arrangement of the machinery in the mill shown on page 70. Although the little wheel is doing an astonishing amount of work, yet the machinery which it drives is not arranged in as simple and complete a manner as the peculiar advantages of our Wheel would permit, the mill having formerly been run by two large overshot wheels. The machinery was arranged and adapted to the overshot wheels. In applying our Wheel, there was no change made in the machinery whatever, hence all the heavy, complicated machinery used with the overshot wheels has to be carried by our little Wheel, which, added to the work of propelling five pairs of large burrs, makes its performance wonderful. We have taken some pains to show the manner of connecting this Wheel to the work, as it is a method that can be frequently adopted where it is desirable to connect our Wheel to the same machinery run by the overshot wheel, and where the machinery, for various reasons, cannot be changed. The burrs are located around the main spur wheel G; the shaft H extends up into the mill running the machinery; the pinion E, which receives the power of the Wheel through the pulley D, works into the spur wheel G, thus driving all or any number of the burrs at one time. The belt, running from the pulley on the water wheel shaft, is 16 inches wide, and runs with a speed of almost 80 feet



SEE PAGE 78 FOR DESCRIPTION.

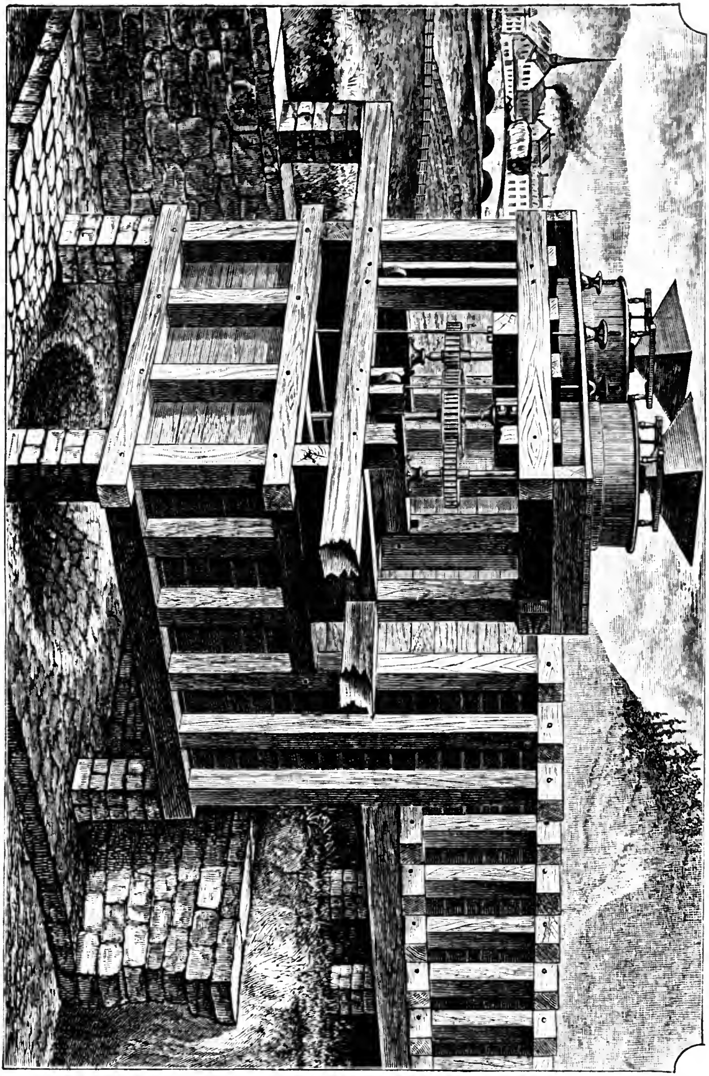
per second. B is the Globe case within which the wheel is placed, and although the pressure on this case is over 43 pounds per square inch, yet it remains perfectly watertight, and shows no signs of undue strain upon it. A is the pipe which conducts the water to the wheel. At I there is a screw and worm wheel, for opening the gates of the wheel, which by this means is done gradually, thus avoiding any sudden shock which might be produced by suddenly opening or closing the gates. The gates of the wheel, under this enormous pressure, are opened with the greatest ease, requiring in fact scarcely more force than if under a fall of only ten feet. The casing B, is firmly bolted to timbers, secured in heavy masonry. In some instances, it may be found convenient to use a short draft tube, but we aim always, where it is possible, to avoid entirely the use of any tube, except a short one cast on the Globe, the end of which should be so located as to touch the standing tail-water.

Decked Penstock—Direct Attachment to Burrs.

There are some mills, particularly flour and saw mills, that are so situated with reference to flume, that it is difficult to gear or attach the spindles, or horizontal shaft to the water wheel shaft above the surface of the water. This frequently happens where the water is on a level with the second or third story of the mill, and the machinery operating on the first floor. In such a case the wheel can be placed. as shown in the accompanying plate. In addition to the ordinary perpendicular portion of flume or penstock, there is a horizontal section flume built in which the wheel is placed. This decking may be three or four feet high on the inside, where the head is about 14 feet and the water wheel of about 23 inches diameter. Other sizes of wheels and other heads require different heights of decking.

This plate shows a shaft that is attached to the wheel shaft, passing out of the top of decking of this horizontal section of flume, and around the shaft is placed a stuffing box to prevent leakage of water; around the gate rod, there being one also for the same purpose. To the upright shaft attached to the wheel, may be applied bevel gears for driving the horizontal shaft for the saw mill, or spur gears may be used as shown in the cut to drive mill burrs. The shaft can be extended upwards between the burrs to which elevators and other machinery can be attached. The advantage of this method of placing the wheel is that the power can be brought nearer to the point where the work is to be done, otherwise it would have to be brought through a long train of gears and shafting, which of course would tend greatly to lessen the usual effect of the wheel.

As the value of any mill depends mainly upon the power to propel it, we would say, conform the machinery, if possible, to the wheel, and not the wheel to the machinery, as it is too frequently done. Bring the work as near the wheels as possible and avoid too great length of shafting and complication of gearing. An excess of shafting and too



much gearing always tend to greater wear and friction, requiring attention, that they may always be in perfect order.

In building this style of flume we cannot too much impress the necessity of having strong, heavy timbers and plank, which ought to be fitted closely, particularly at the joints, elbows or turns. The husk or frame support of millstone is built entirely upon a separate foundation, resting upon stone walls, piers and abutments as will be seen. The corner posts may be considerably heavier than the illustration indicates, and two or three others should be framed in the long part or side next to view, and from this to the upper horizontal plate, diagonal pieces may be framed or securely nailed to give it the greatest possible stiffness and strength. By building the frames separate from the penstock, either of them can be renewed at any time, that it may become necessary.

Open Penstock—Direct Attachment to Burrs, Page 75.

A plain, substantial flume is constructed with good, heavy timbers and a firm foundation. The stone piers and the back wall may be placed upon planking, as illustrated in the cuts on pages 75 and 87, providing the foundation is a soft one; or upon stone providing the bottom of the pit is of that material. In all cases, however, the level of the tail water when standing, ought to be as high as the top surface of the lowest sill. The space below the sills in the cut was left that the placing of the sill on the wall and the pier might be observed; but in practice the water should cover all of these, that the full benefit of the head and fall may be realized, by means of a tube or cylinder extending downward from the wheel, touching the water when in operation, and thus excluding the air and utilizing the full power.

There should be sufficient space, both in depth and width between the floor of the flume and the floor of the tail race, to let the water pass out freely and without obstruction from beneath the flume or penstock. The floor of this penstock should be of heavy planking to give sufficient firmness to support the combined weight of water and the wheel with the shafting and gearing. In the floor of this penstock there should be cut a hole of sufficient size to admit the cylinder of wheel casing, which will pass through the floor of the penstock, thus allowing the wheel to rest, by means of the flange of its casing, upon the floor. It will not require anything to fix it to its place, as the weight of the wheel and water will hold it firmly in position. The penstock is a mere continuation of the flume or forbay, as the cut shows, excepting that it has a little greater depth and strength; the planking of the forbay or flume being merely extended into the penstock. This penstock should in every case be made according to the dimensions in column F of the tables on pages 27 and 33, accompanying the cuts on preceding pages 26 and 32. The floor of the penstock it must be remembered, should come sufficiently near the standing tail water that the end of the cylinder projecting downward from the wheel casing through the floor

will dip two or three inches below the surface of the water, as the cut on page 26 already alluded to clearly illustrates.

A pit of good depth should always be dug underneath the flume in all cases, to prevent the water from reacting upon the wheel, whereby the amount of power would be diminished. This penstock can be constructed to suit the peculiarities of the location, the essential points to observe being, to have it strong enough and of sufficient capacity to let the water to the wheel without obstruction. In the illustration the mill stone husk is shown upon the penstock timbers; it may be built separately from this, and independent of it, as will be found in cut on page 75. The timbers supporting the burrs may be heavier, and more of them than is shown here; and diagonal braces may also be used for stiffening and making the husk more solid and substantial.

Percentage Tests of Water Wheels.

The general introduction of the Turbine Wheel as a motor was immediately followed by attempts, with varying degrees of success, to devise some means of testing or measuring its power in the different forms in which it was constructed. Up to the present time the method generally adopted has been the use of the friction brake, dynamometer, and the lifting of weights. While this method of testing a wheel appears a simple one, and should apparently yield definite results, it has been found in the experience of manufacturers of wheels and in that of practical mill-owners, to be entirely unreliable as an indicator of the amount of work the wheel will perform. We have held this view of the matter for years, in our publications and correspondence. As an example of the position which we have taken upon this subject, and still maintain, we make the following extract from our pamphlet issued in 1867:

"The ordinary method of determining the ratio of useful effect produced by a wheel from a certain quantity of water is by means of a friction brake, or by raising weights, where the quantity of water and the height through which it falls, or in other words, the amount of head and fall employed, is carefully compared with the amount of resistance overcome. Thus what is called the percentage of power is accurately obtained. Now, while, in a scientific sense, to ascertain the percentage of a wheel is of some value, and to which formerly much importance was attached, it has become a well-established fact, from the many careful tests made by individuals and corporations, that the co-efficient of useful effect thus determined cannot be held as a measure of the efficiency of a wheel, or taken as any assurance that the same comparative results will be obtained, when applied to the various purposes of manufacture. Before this fact was fully established it was a matter of much astonishment not only to manufacturers, but to the builders of wheels themselves, to find a great disparity existing between the results obtained in an experimental test and the results produced when practically applied to propel machinery. So great has been this difference that many wheels which, from the high per cent. obtained

by test trials, gave flattering promise of a successful and economical wheel, when required to overcome the ever-changing resistance of machinery, have totally failed to meet the requirements of an economical wheel. So frequently have these failures occurred that it forms one of the great obstacles of introducing a really valuable and successful wheel; and it is an ordinary thing for shrewd and careful manufacturers to say: '*We know beautiful results can be produced before test committees, but what will your wheel do in my mill?*'"

It is a well-authenticated fact that in an experimental test of the kind above described, a number of wheels widely differing in their actual practical efficiency may give an almost uniform percentage of power—the experience of manufacturers showing that of those very wheels some will do nearly double the actual work performed by others.

One of the most memorable and instructive cases of this kind on record was the competitive test of water wheels at the Fairmount Water Works, in Philadelphia, in 1859-60. It is an unquestioned fact, and one within the knowledge of all manufacturers of wheels, that in the Fairmount test, in which the lifting of weights was the criterion of effect, several wheels gave nearly 90 per cent. of power, while others were not far behind; and that wheels which gave the most flattering percentage in the test were found in their subsequent practical operation to be of comparatively little value, while other wheels which stood relatively low in the experimental scale proved to be in practice far more effective than those which yielded the larger percentage. We cite the Fairmount test not only because it was a signal instance of the deceptive results of a trial by percentage, but also for the reason that the attention of mill-owners was largely drawn to it as one of the most exhaustive and searching tests ever undertaken. That it was thoroughly and carefully conducted is shown by the completeness of the preparations. The apparatus for the test was constructed under a liberal appropriation by the City Council of Philadelphia, and neither pains nor expense was spared. The amplest provision was made in money, material, and skill for the demands of the occasion, and manufacturers of turbines were invited to send or bring wheels to be tested, without extorting or impelling the payment of a fee. And in order to avoid any false computation which might possibly occur from the measurement of water by the use of a weir (which is liable to erroneous results,) an absolutely certain method was adopted, the water being caught in a large tank and measured with perfect accuracy.

In the ascertaining of the useful effect or percentage the liability to error involved in the use of the ordinary appliances was avoided by substituting the lifting of weights, and in every particular the trial was beyond criticism in the minute precision with which its fundamental theory was applied. No one can question the ability with which the test was conducted. It was superintended by the best engineering talent in the country, and no candid man can read the admirable and exhaustive report of the trial (which is contained in a large and handsomely illustrated pamphlet,) without being convinced of the thorough-

ness, skill, and impartiality which characterized it in every respect.

Yet, after all, of what practical value was this test? What did it teach? Simply nothing except the inadequacy of such tests to reveal those peculiar properties of the water wheel which constitute its value as a practical motor. The very wheel which gave the highest percentage of power at Fairmount, when put to the test of propelling machinery by the manufacturing community, was found inadequate and inefficient; and the maker of that wheel having at length abandoned it, after endeavoring for several years to put it on the market, adopted in its stead a wheel belonging to the class which gave the lowest percentage in the Fairmount test, and is now engaged in its manufacture, with much better results than with his former wheel. Other wheels, moreover, which fell far behind in the Fairmount trial, have since attained a more eligible position in the esteem of the manufacturing community than the wheels which surpassed them in the experimental tests.

While such tests may to some degree or in a measure, in the hands of entirely competent and honest parties, give comparatively reliable results, under particularly favorable circumstances, they cannot afford truthful indications of the operation of a wheel, which is subject not only to unfavorable circumstances in location, etc., but to constantly changing speeds under various conditions. With a percentage test the wheel is tried but a few seconds, at a perfectly uniform speed, discharging the same quantity of water for each interval of time, with the flume and pit in the very best possible condition, both for entrance and discharge of water. The gateage is then probably changed, and a few seconds' test made in that manner, under the same uniform conditions as at first; and so on are a number of such tests made. In practice, the wheels are, perhaps, in a majority of cases, operating under very unfavorable circumstances, not only as to the entrance and discharge of water to and from the wheel, but as to the size and proportion of the gears, and the location of the wheel in relation to the work to be done. The motion, especially in woolen, cotton, and saw mills, is ever changing, exceedingly unsteady, and these changes by no means in a uniform degree, and of course discharging for each interval of time different quantities of water than where the conditions are uniform and favorable, as in the test flume. In such cases no percentage test, however carefully devised and conducted, will afford an exponent indicating the real obtainable power, particularly when the experiment is made under the unfavorable conditions to which we have already alluded. As a consequence, some wheels which, by the percentage method, give a high and uniform result, will fall far below more ordinary wheels in their average work when submitted to this ever-varying routine of change.

Aside from the inability of percentage testing to prove the actual worth of a wheel for driving various kinds of machinery, should it be done even in an honest and competent manner, it proves nothing whatever as to the durability of a wheel, or as to its general manage-

ment when it has been once in operation a number of years. This requires the practical operation of a large number, many of which have been running for several years, before all the points of merit and demerit become apparent or fully demonstrated. So also is the ease of repairing and the liability of breakage only subject to demonstration by actual use.

In view of the failure of all tests of the character above described, to indicate the actual available merits of the competing wheels, we are led to the unavoidable conclusion that the only reliable test of the power of a water wheel is its practical working, whether in grinding grain or the propelling of machinery, under the varying conditions which it is destined to encounter, and for a length of time sufficient to exemplify those conditions and reveal their effect.

In the foregoing remarks we have had in view only those few tests which are at least honestly and fairly made, and about which there is no fraud, pretence, or intended deception. There are "tests," so-called, of which we frequently hear, but which might more justly be called conspiracies. We refer to the "tests" which builders of water wheels in competition with the Leffel Wheel often profess to have made, publishing the alleged results with an immense flourish of trumpets, and claiming, of course, to have achieved a brilliant victory over the Leffel Wheel. The fact has in almost every instance proved to be that these parties had held a private test to suit their own ideas and interests, and entirely without our knowledge or consent.

Sometimes we are informed, from some distant part of the country, by some unknown builder of wheels, that he is about to make a test against our wheel in some mill, and that we must appear on the ground and see that our wheel is in order, which has perhaps been in operation a number of years. We are commanded by such novices as though we had nothing to occupy our time, or our business had no claims upon our attention, and as though it were our duty to aid in making them and their wheel a reputation, or at least to give them influence by a recognition of their wheel. They, however, do not desire our presence, but it is done, in such cases as reach our notice, for the sole purpose of a pretence to be fair, and to influence spectators or judges. Fairness and honesty is not what they want; it is their desire to test in our absence. It would be a very poor wheel which could not beat the Leffel under such circumstances, however much it might fall short of it in actual merit and practical value. The invariable selection of the Leffel Wheel, however, as a standard of comparison by opposition wheel builders, and their extreme anxiety to make it appear, by fair means or foul, that their wheel is equal or superior to the Leffel, is one of the most striking proofs which can be afforded that it is beyond dispute the best water wheel in use.

"He Told the Full Truth About the Wheel."

OSVKA, MISS., May 28th, 1884.

Messrs. James Leffel & Co.:

I am just in receipt of a letter from Helena, Ark., making inquiries about the Leffel Wheel. I write to him to-day the full truth about the wheel. Since it was put in on August 17th, 1877, till the present writing, nearly seven years, it has never had to be loooked at--neither wheel nor gate has ever been out of order. It has ginned six crops of cotton and done our grinding; cut all the oat straw, and for two years has had a circular saw. There are a number of your wheels here in reach of my observation, that have been running for years, and I have never heard any kind of complaint urged against one of them, nor have I heard of an owner who was dissatisfied. I send you the letter as you may wish to write to him. Your wheel has run two terms, and we are by it like by the President, we have no desire to make a change.

T. E. TATE.

Pulp Mill—Two 87 Inch Wheels at 2-3 Gates.

APPLETON, WIS., Jan. 1st, 1883.

Messrs. James Leffel & Co., Springfield, O.:

GENTLEMEN—I am using two of your 87 inch Wheels in my pulp mill at Grand Rapids, Wis. They are giving entire satisfaction. Under a ten foot head and with a two-thirds gate, they give ample power to drive four pulp grinders, a refiner, pump, and two saws. I am making from three and one-half to four tons of dry pulp every twenty-four hours, and have ample power to make from one to two tons more, during the same period. I have used several other make of water wheels, but yours gives better results, using less water, than any other I have tried.

Yours truly, WELCOME HYDE.

On Half Gate, 4 Feet Fall.

SAN JUAN MILL, BEXAR CO., TEX., April 3, 1885.

Messrs. James Leffel & Co., Springfield, O.:

DEAR SIRS—Am well satisfied with the 50 inch Special you sold me. The Wheel has been running now about 7 months, and I never, so far, have had any trouble with it. With four feet fall at about half gate, it drives easily the corn mill, &c.: occasionally a corn elevator and a sheller, as well as a hominy machine. I can well recommend yours to any man who wants a reliable wheel.

Yours truly, F. E. GROTHAUS.

On Part Gate and on its Merits.

YANKTON, DAK., April 2, 1885.

James Leffel & Co., Springfield, O.:

We are running the 10 inch Leffel Water Wheel under a 30 foot head. We run this wheel on feed and corn meal altogether at 5/8 to 3/4 gate; grind about 15 bushels meal per hour or about 25 bushels feed. As far as the wheel giving satisfaction is concerned, I never had a failure in the Leffel Wheel, having used and sold a great many on their merits.

Yours, &c.,
ROLLER KING MILLING CO.,
S. Kaucher, Supt.

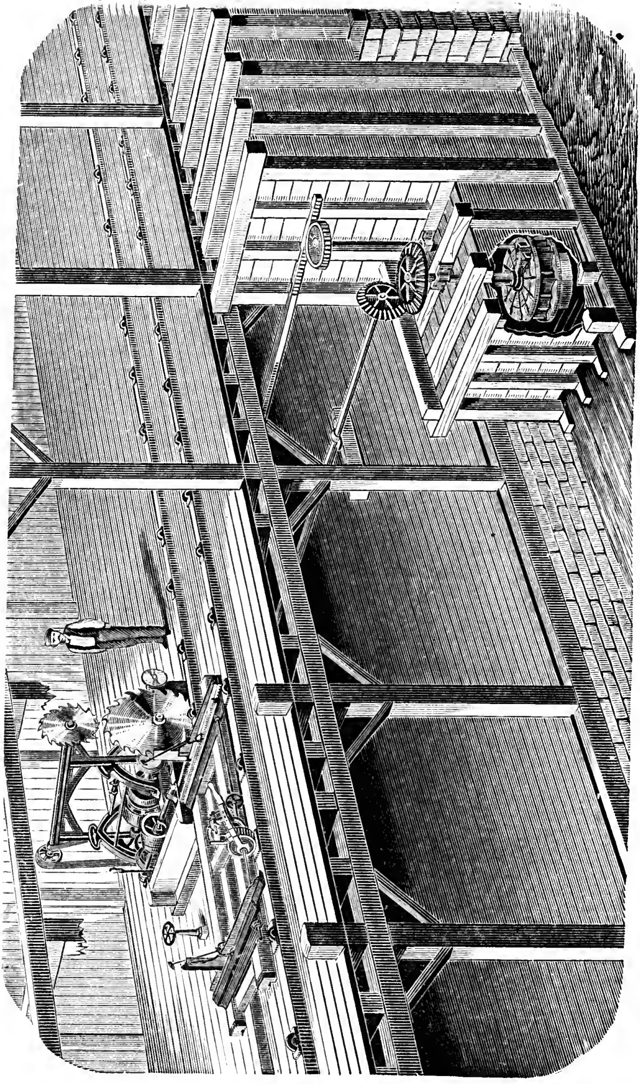
On Quarter Gate and 2 1-2 Feet Head.

BANCROFT, MICH., April 1, 1885.

James Leffel & Co.:

DEAR SIRS—We can say that the 56 inch Water Wheel that we bought of you gives entire satisfaction. We use it in the manufacturing of Excelsior under a five foot head. We have five machines, one saw and press, and it will run the whole thing with 1/4 gate, and can run the whole mill with 2 1/2 feet head at such a time as high water.

Yours truly,
SHIAWASSEE EXCELSIOR CO.



Saw Mill.—Explanation of Plate on Foregoing Page.

This cut illustrates a first-class circular saw mill, built in the most recent and modern style, and supplied with all the arrangements and conveniences for manufacturing a large amount of lumber; although the minor details are omitted in the illustration, that the circular mill, penstock and connection of wheel, saw and work, may be exhibited on a scale of sufficient size, without complications, to render the general plan easily understood. The water wheel in this case may be our 30½ or 35 inch, under a 14 or 15 feet head of water, and located as the design represents, in a decked penstock, built precisely upon the principle and in the manner of that shown on page 87, except that perhaps in that case the wheel is smaller and penstock higher, necessitating somewhat more strength in the posts and planking although not requiring so great internal dimensions as in the cut before us; since the lower the head the less pressure, and consequently the less resistance required in posts and planking, with, however, nearly the same aggregate strength in the floor planking amd sills, for the lower head, requiring as it does a larger floor and more space, with also larger wheels.

This same plan is also given in a general way on page 75, though a more portable and not so substantial a form as our cut here illustrates. It is by no means essential that the decked penstock in all cases should be used for saw mills; it usually happens, however, where the head is more than an average height, it becomes necessary for the sake of convenience, that the power be taken off below the level of head water, in which case the decked penstock is required, or a better substitute in the Globe Casing as illustrated on pages 22, 55, 65 and 72. In many instances where the head water and penstock are low, and the floor of mill of modern height, a method may be adopted, in which there is no decking or offset used, the wheel being simply set or located in the open penstock, with its shaft extending above the cap timbers, a gear on this shaft connecting with the one on the horizontal shaft, and conducting the power under the main floor, where it can be taken off by means of a pulley and belt, and transmitted through the floor to the pulley on saw mandrel as our cut here exhibits; or it may be connected direct to an upright mill by gearing, as cut on page 77 represents; or may be used upon a crank shaft of upright saw under the mill by a belt.

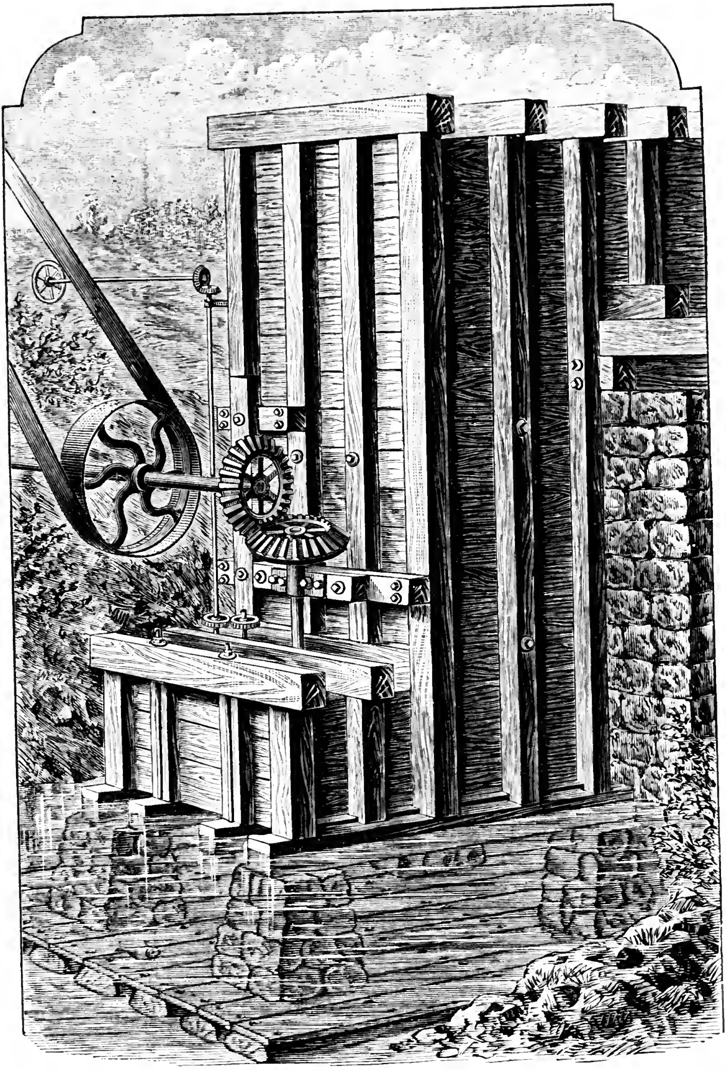
The principle of communicating the power, conducting it to the proper location, and connecting it to the saw mill, which may be either circular or upright, is precisely similar, whether the Decked, Globe or Open Penstock is used, as may be seen by a comparison of the illustrations on pages 65, 77, 84 and 96, although each different case may require some slight modifications, by which the particular circumstances may each be adapted the one to the other, yet by no means departing from the general principle or arrangement as stated above. In the cut, the driving pulley on main horizontal line shaft and th

belt are not shown, as they are near and under the floor; the belt passes through the floor and connects with the pulley on saw mandrel, being almost or entirely out of the way of the workmen and lumber; if for any purpose it is considered desirable, the main line may be placed higher, when a part of pulley and belt would be above the floor. The gate arrangement beyond the log carriage can be located at any convenient point, and under the floor may be attached by a gear or rack connections to the gate rod at water wheel.

Parties applying to us for any information concerning the adaptation of water wheels to saw mills, should always give as full and complete a statement of the circumstances in the case as possible; stating whether a mulay, sash, gang or circular mill; the amount of head water, and probable size of stream, which may be estimated by directions given elsewhere in pamphlet, or by letting us know how far above or below other mills you are, if any, and what amount of work they are doing in 24 hours. State also size and capacity of your proposed mill, and particularly the size and kind of saw, whether circular or upright, and what kind and amount of timber you intend cutting in inch measure per hour, or per day of twelve hours. All these conditions modify more or less the size and adaptation of water wheel to the proposed work.

Description of Illustration on Following Page.

The cut exhibits in a clear and distinct manner, a style of flume and penstock, often employed in cases where the power is to be taken off or applied below the level of head water. It is termed usually, a decked penstock; and is variously modified in its construction, although in no case differing, in general principle, materially from that shown in this instance. The illustrations on pages 84 and 96 are of the same design and idea; but vary somewhat in the detail of constructions. In the one on page 84 it will be observed, the decking is upon the same side of the upright; instead of the front as seen in the cut before us, it can be used, or the wheel placed on either side or front, as circumstances may require in each particular instance. The building and general arrangement of the penstock need hardly be described; each detail being so carefully shown as to convey at once a correct idea of the whole affair. It might be stated, that to insure durability and general efficiency, it should be made strong and tight, using heavy timbers and planking; the latter well-jointed, with a short bevel on the inner edge of each plank, to admit of caulking or stopping of any small leaks, by the collection of sediment or small floating particles. The planking may be tongued and grooved if preferred; but in no case should the lumber be entirely dry nor altogether green; if too dry, the planking would swell and bulge off its bearings, and if too green, would shrink, leaving the penstock loose and leaky, when left a few days exposed to the air, with the water out of the flume and bulkhead, or penstock.



The cut shows the sills or foundation, with planking on them, all laid on the bottom of a dry pit, upon which the stone piers are placed. The cut on page 77 has the piers resting directly upon a stone bottom, without the sills or planking, they being unnecessary where such a foundation can be obtained. The piers must in all cases be carefully and solidly laid up (water cement being preferable to mortar,) since the entire weight of all the wood work, water, water wheel, with some of the shafting and gearing must rest upon them. In neither of these cases, in fact in no case, must it be inferred, that the penstock bottom or the foundation planking must stand thus above the tail-water. The level of tail-water, while standing or running, *should* and *must* stand on a level with the top of the sills placed on the top of stone piers, on which the plank of decking and main part of decking, and main part of penstock are placed; if the very best results are desired. An inch or two lower than this, or two or three inches higher than the top of these sills, will not affect the results in a material manner; but beyond these limits, a decrease of power may be expected. The planking should be well nailed to each post, wherever it touches them, by this means preventing them from spreading or pulling apart, and avoiding the necessity of cross ties framed into the posts. The bottom planks are supported by sills and ties, the ends of the plank being seen projecting through on the side, lying on the side sill, and securely nailed to its resting place. The two middle sills are supported by rods or bolts.

Explanation of Tables on Pages 89, 90, 91.

The following tables are taken from "Leffel's Construction of Milldams and Bookwalter's Millwright and Mechanic"; published by Jas Leffel & Co. The calculations for these tables have been carefully made from the formula of Weisbach; and will be found extremely useful, in determining the available power of water, moving at any velocity, from one to twenty feet per second, through pipes from nine to thirty inches inside diameter. The length of pipe for which the table is calculated is 100 feet. As however, the loss of head by friction, varies in the same direct ratio as the length of the pipe, the amount of such loss in a pipe of greater or less length than 100 feet, can be easily ascertained.

For example: to find the loss of head in a pipe 47 feet long, 9 inches inside diameter, discharging 79.41 cubic feet of water per minute. This rate of discharge, as will be seen by the table, indicates a velocity of 3 feet per second. The loss of head is found in the column for 9 inch opposite the figure 3 in the column of velocities, viz.: 45-100 of a foot for a pipe 100 feet long. For a pipe 47 feet long it will be forty-seven hundredths of .45 feet, or .45 multiplied by .47, making 21-100 feet, dropping decimals below the second place. That is, for one foot of pipe the loss is .45 divided by 100, and for 47 feet, forty-seven times the loss of one foot.

LOSS OF HEAD BY FRICTION OF WATER IN PIPES.

Calculated for Pipes 100 Feet Long.

Velocity of Water through Pipe in Feet per Second.	INSIDE DIAMETER OF PIPE IN INCHES. 9		10		11		12		13		14	
	Discharge per Min. in Cubic Feet........	No. of Ft. Loss of head due to friction	Discharge per Min. in Cubic Feet........	No. of Ft. Loss of head due to friction	Discharge per Min. in Cubic Feet........	No. of Ft. Loss of head due to friction	Discharge per Min. in Cubic Feet........	No. of Ft. Loss of head due to friction	Discharge per Min. in Cubic Feet........	No. of Ft. Loss of head due to friction	Discharge per Min. in Cubic Feet........	No. of Ft. Loss of head due to friction
1	26.47	.065	32.70	.059	39.55	.054	47.10	.049	55.30	.045	64.08	.042
2	52.94	.220	65.40	.198	79.10	.180	94.20	.164	110.60	.152	128.16	.141
3	79.41	.450	98.15	.407	118 65	.370	141.30	.339	165.90	.313	192.24	.291
4	105.90	.760	130.85	.685	158.20	.623	188.40	.570	221.20	.527	256.32	.489
5	132.37	1.14	163.50	1.03	197.76	.932	235.40	.855	276.50	.789	320.40	.735
6	158.84	1.59	196.20	1.43	237.30	1.30	282.50	1.20	331.80	1.10	384.48	1.03
7	185.31	2.12	228 90	1.90	276.85	1.73	329.60	1.59	387.10	1.46	448.57	1.36
8	211.80	2.71	261.60	2.45	316.40	2.23	376.70	2.04	442.40	1.88	512.66	1.75
9	238.29	3.37	294.29	3.03	355.95	2.76	423.80	2.53	497.70	2.33	576.75	2.17
10	264.77	4.11	327.00	3.70	395.50	3.36	470.90	3.08	553.00	2.85	640.84	2.64
11	291.26	4.90	359.70	4.41	435.05	4.01	518.00	3.68	608.30	3.39	704.93	3.15
12	317.74	5.77	392.39	5.19	474.62	4.72	565.10	4.32	663.60	3.99	769.02	3.71
13	344.22	6.70	425.09	6.03	514.17	5.48	612.20	5.03	718.90	4.64	833.10	4.30
14	370.70	7.71	457.79	6.93	553.72	6.30	659.30	5.78	774.20	5.33	897.18	4.95
15	397.18	8.77	490.49	7.90	593.27	7.18	706.35	6.58	829.50	6.08	961.27	5.64
16	423.65	9.91	523.18	8.92	632.82	8.11	753.45	7.43	884.75	6.86	1025.36	6.37
17	450.13	11.11	555.88	10.00	672.37	9.09	800.50	8.33	940.00	7.69	1089.45	7.15
18	476.61	12.38	588.58	11.14	711.92	10.13	847.60	9.29	995.30	8.57	1153.54	7.96
19	503.08	13.71	621.28	12.34	751.52	11.22	894.70	10.28	1050.60	9.49	1217.63	8.81
20	529.56	15.11	653.98	13.60	791.07	12.36	941 75	11.33	1105.90	10.46	1281.72	9.71

LOSS OF HEAD BY FRICTION OF WATER IN PIPES.—Continued.

Calculated for Pipes 100 Feet Long.

Velocity of Water through Pipe in Feet per Second.	INSIDE DIAMETER OF PIPE IN INCHES.											
	15		16		17		18		19		20	
	Discharge per Min. in Cubic Feet	No. of Ft. Loss of head due to friction	Discharge per Min. in Cubic Feet.........	No. of Ft Loss of head due to friction	Discharge per Min. in Cubic Feet........	No. of Ft. Loss of head due to friction	Discharge per Min. in Cubic Feet........	No. of Ft. Loss of head due to friction	Discharge per Min. in Cubic Feet........	No. of Ft. Loss of head due to friction	Discharge per Min. in Cubic Feet........	No. of Ft. Loss of head due to friction
1	73.58	.039	83.68	.037	94.56	.035	106 00	.033	118.09	.031	130.87	.029
2	147.16	.132	167.36	.123	189.12	.116	212.00	.110	236.18	.104	261.74	.099
3	220.74	.272	251.04	.255	283.68	.239	318.00	.225	354.27	.214	392.61	.204
4	294.32	.457	334.72	.428	378.24	.403	424.00	.380	472.36	.361	523 48	.343
5	367.90	.683	418.40	.640	472.80	.601	530.00	.570	590.45	.537	654.35	.515
6	441.48	.957	502.08	.895	567.36	.841	636.00	.795	708.54	753	785.22	.715
7	515.07	1.27	585.76	1.19	661.92	1.12	742.00	1.06	826.63	1.00	916.09	.950
8	588.66	1.63	669.45	1.53	756.48	1.44	848.00	1.36	944.72	1.29	1046.96	1.23
9	662.25	2.02	753.14	1.89	851.04	1.78	954.00	1.68	1062.81	1.59	1177.83	1.51
10	735.84	2.46	836 83	2.31	945 60	2.18	1060.00	2.06	1180 90	1.95	1308.70	1.85
11	809.43	2.94	920.52	2.76	1040.16	2.59	1166.00	2.45	1298.99	2.32	1439.57	2.21
12	883.02	3.46	1004.21	3.24	1134.72	3 05	1272.00	2.89	1417.08	2.73	1570.44	2.59
13	956.60	4.02	1087.90	3.77	1229.28	3.55	1378.00	3.35	1535.17	3 17	1701.31	3.02
14	1030.18	4.62	1171.59	4.33	1323.84	4.08	1484.00	3.86	1653.26	3.65	1832.18	3.47
15	1103.77	5.26	1255.28	4.93	1418.40	4 65	1590.00	4.38	1771.35	4.16	1963.05	3.95
16	1177.36	5.94	1338.96	5.58	1512.96	5 25	1696.00	4.96	1889.44	4.69	2093.92	4.46
17	1250.95	6.67	1422.64	6.25	1607.52	5.88	1802.00	5.55	2007.53	5 26	2224.79	5.00
18	1324.54	7.43	1506.32	6.97	1702.08	6.55	1908.00	6.19	2125.62	5 86	2355.66	5 57
19	1398.13	8.22	1590.00	7.71	1796.64	7.26	2014.00	6.86	2243 71	6.49	2486.53	6.17
20	1471.72	9.06	1673.68	8.50	1891.20	8.00	2120.00	7.56	2361.80	7.16	2617.40	6.80

LOSS OF HEAD BY FRICTION OF WATER IN PIPES.—Continued.

Calculated for Pipes 100 Feet Long.

Velocity of Water through Pipe in Feet per Second.	INSIDE DIAMETER OF PIPE IN INCHES. 22		24		26		28		30	
	Discharge per Min. in Cubic Feet........	No. of Ft. Loss of head due to friction	Discharge per Min. in Cubic Feet........	No. of Ft. Loss of head due to friction	Discharge per Min. in Cubic Feet	No. of Ft. Loss of head due to friction	Discharge per Min. in Cubic Feet........	No. of Ft. Loss of head due to friction	Discharge per Min. in Cubic Feet........	No. of Ft Loss of head due to friction
1	158.36	.027	188.44	.025	221.13	.023	256.56	.021	294.44	.019
2	316.72	.090	376.88	.082	442.26	.076	513.12	.071	588.88	.066
3	475.08	.195	565.32	.169	663.39	.157	769.68	.145	883.32	.136
4	633.44	.312	753.76	.285	884.52	.263	1026.24	.245	1177.76	.228
5	791.80	.466	942.20	.428	1105.65	.394	1282.80	.368	1472.20	.342
6	950.16	.650	1130.64	.600	1326.78	.550	1539.36	.515	1766.64	.478
7	1108.52	.865	1319.08	.795	1547.91	.730	1795.92	.680	2061.08	.635
8	1266.88	1.12	1507.52	1.02	1769.04	.940	2052.48	.875	2355.52	.815
9	1425.24	1.38	1695.96	1.27	1990.17	1.17	2309.04	1.08	2649.96	1.01
10	1583.60	1.68	1884.40	1.54	2211.30	1.42	2565.60	1.32	2944.40	1.23
11	1741.96	2.01	2072.84	1.84	2432.43	1.69	2822.16	1.57	3238.84	1.47
12	1900.32	2.36	2261.28	2.16	2653.56	2.00	3078.72	1.86	3533.28	1.73
13	2058.68	2.74	2449.72	2.52	2874.69	2.32	3335.28	2.15	3827.72	2.01
14	2217.04	3.15	2638.16	2.89	3095.82	2.67	3591.84	2.48	4122.16	2.31
15	2375.40	3.59	2826.60	3.29	3316.95	3.04	3848.40	2.82	4416.60	2.63
16	2533.76	4.06	3015.04	3.72	3538.08	3.43	4104.96	3.19	4711.04	2.97
17	2692.12	4.55	3203.48	4.17	3759.21	3.85	4361.52	3.58	5005.48	3.33
18	2850.48	5.07	3391.92	4.65	3980.34	4.29	4618.08	3.98	5299.92	3.72
19	3008.84	5.61	3580.36	5.14	4201.47	4.75	4874.64	4.41	5594.36	4.11
20	3167.20	6.18	3768.80	5.67	4422.60	5.23	5131.20	4.86	5888.80	4.53

Velocity, Discharge and Power of Nozzles

Head in Feet.	Velocity per Second in Feet.	Diameters of Nozzles.													
		1 in.		1½ in.		2 in.		2½ in.		3 in.		3½ in.		4 in.	
		cu. ft.	H. P.	cu. ft.	H. P.	cu. ft.	H. P.	cu. ft.	H. P.	cu. ft.	H. P.	cu. ft.	H. P.	cu. ft.	H. P.
1	8.02	.041	.004	.093	.010	.164	.018	.255	.029	.372	.040	.50	.056	.656	.072
1½	9.83	.050	.008	.111	.019	.200	.034	.312	.053	.444	.076	.61	.105	.800	.136
2	11.35	.058	.013	.130	.029	.232	.052	.360	.082	.520	.116	.70	.160	.628	.208
2½	12.68	.064	.018	.145	.041	.256	.072	.402	.114	.589	.164	.79	.224	1.02	.288
3	13.90	.069	.024	.159	.054	.284	.096	.440	.150	.636	.216	.86	.295	1.14	.384
3½	15.01	.076	.030	.171	.068	.304	.120	.475	.189	.684	.272	.94	.370	1.22	.480
4	16.05	.081	.037	.183	.083	.324	.148	.507	.231	.742	.332	1.02	.452	1.30	.592
4½	17.02	.086	.044	.194	.099	.344	.176	.540	.275	.776	.396	1.06	.540	1.38	.704
5	17.95	.091	.051	.205	.113	.364	.204	.567	.315	.820	.452	1.11	.600	1.46	.816
6	19.66	.100	.068	.224	.153	.400	.272	.622	.425	.896	.612	1.22	.833	1.60	1.09
7	21.23	.108	.086	.242	.193	.43[illegible]	.344	.672	.535	.968	.772	1.32	1.05	1.73	1.38
8	22.70	.116	.104	.260	.252	.464	.416	.720	.656	1.04	.928	1.40	1.28	1.85	1.66
10	25.38	.129	.146	.290	.329	.516	.584	.805	.915	1.16	1.32	1.57	1.79	2.16	2.34
12½	28 37	.144	.204	.324	.460	.576	.816	.897	1.28	1.30	1.84	1.76	2.50	2.30	3.46
15	31.08	.158	.269	.355	.505	.632	1.08	.985	1.68	1.42	2.42	1.93	3.29	2.53	4.32
17½	33.57	.170	.339	.383	.782	.680	1.36	1.06	2.11	1.53	3.13	2.08	4.20	2.72	5.44
20	35.89	.182	.414	.410	.931	.728	1.66	1.14	2.58	1.63	3.72	2.23	5.07	2.91	6.64
22½	38.07	.193	.494	.435	1.11	.772	1.98	1.21	3.08	1.74	4.44	2.36	6.05	3.09	7.92
25	40.13	.204	.578	.458	1.30	.816	2.31	1.27	3.61	1.83	5.20	2.54	7.08	3.26	9.24
27½	42.08	.213	.667	.480	1.50	.852	2.67	1.33	4.17	1.92	6.00	2.61	8.17	3.41	10.68
30	43.95	.228	.760	.513	1.71	.912	3.04	1.42	4.75	2.05	6.84	2.70	9.31	3.65	12.16
32½	45.75	.232	.857	.522	1.93	.928	3.43	1.45	5.35	2.09	7.72	2.84	10.50	3.71	13.72
35	47.47	.241	.958	.542	2.15	.964	3.83	1.51	5.98	2.17	8.60	2.95	11.71	3.86	15.32
40	50.75	.257	1.17	.379	2.63	1.03	4.68	1.61	7.31	2.32	10.52	3.15	14.33	4.12	18.72
45	53 83	.273	1.40	.614	3.14	1.09	5.60	1.71	8.23	2.46	12.56	3.34	17.10	4.36	22.40
50	56.75	.288	1.64	.648	3.68	1.15	6.56	1.79	10.2	2.59	14.72	3.52	20.03	4.60	26 24
60	62.16	.315	2.15	.709	4.84	1.26	8.60	1.97	13.4	2.84	19.36	3.86	26.32	5.04	34.40
70	67.14	.341	2.71	.766	6.10	1.36	10.8	2.13	16.9	3.06	24.40	4.17	33.17	5.42	43.36
80	71.78	.364	3.31	.819	7.45	1.46	13.2	2.27	20.6	3.28	29.80	4.46	40.55	5.84	52.96
90	76.13	.386	3.95	.864	8.88	1.54	15.8	2.44	24.6	3.46	35.52	4.73	48.37	6.16	63 20
100	80.25	.407	4.63	.916	10.4	1.63	18.5	2.54	28.9	3.66	41.64	4.98	56.67	6.52	74.08
125	89.72	.455	6.47	1.02	14.1	1.82	25.8	2.84	40.4	4.08	58.20	5.57	79.20	7.28	103.5
150	98.28	.499	8.60	1.12	19.1	2.00	34.0	3.11	53.1	4.48	76.48	6.10	104.1	8.00	136.0
175	106.1	.539	10.7	1.21	24.0	2.16	42.8	3.36	66.8	4.84	96.28	6.60	131.5	8.04	171.2
200	113.5	.576	13.1	1.29	29.4	2.30	52.4	3.59	81.7	5.10	117.7	7.06	160.2	9.20	219.6
250	127.1	.644	18.3	1.45	41.1	2.58	73.2	4.02	114.	5.87	164.5	7.88	223.9	10.3	292.8
300	139.0	.705	24.0	1.59	54.0	2.82	96.9	4.40	150.	6.36	216.3	8.63	294.3	11.2	284.0
350	150.1	.762	30.3	1.71	68.1	3.05	121.	4.76	189.	6.84	272.6	9.33	371.2	12.2	484.8
400	160.5	.814	37.0	1.83	83.2	3.26	148.	5.09	231.	7.3	323.0	9.97	453.2	13.0	592.0
450	170.2	.864	44.2	1.94	99.3	3.46	176.	5.40	276.	7.76	497.4	10.5	541.0	13.8	707.0
500	179.4	.910	51.7	2.05	116.	3.64	206.	5.69	323.	8.20	466.0	11.1	627.0	14.5	827.2
550	188.2	.955	39.7	2.10	134.	3.82	238.	5.96	372.	8.40	536.8	11.0	731.0	15.2	955.2
600	196.6	.999	68.0	2.23	152.	3.99	272.	6.23	475.	8.92	611.0	12.2	832.7	16.9	1088.
700	212.3	1.06	85.7	2.46	192.	4.36	342.	6.79	535.	9.84	771.2	13.3	1051.	17.4	1371.
800	226.9	1.15	104.7	2.58	235.	4.60	418.	7.19	654.	10.3	942.0	14.1	1282.	18.4	1675.
900	240.7	1.22	124.9	2.75	281.	4.88	499.	7.63	780.	11.0	1124.	14.9	1530.	19.5	1998.
1000	253.8	1.29	146.2	2.89	329.	5.16	584.	8.04	914.	11.5	1316.	15.7	1791.	20.6	2339.

Explanation of above Table of Nozzles.

The above table is given, representing the theoretical velocity, discharge and power of different quantities of water as passed by different nozzles, under heads ranging from one foot to a thousand feet, arranged from formula by Randall. The first perpendicular column represents the head of water in feet, and the second column the theoretical velocity with which the water issues per minute, when entirely unobstructed,

The third perpendicular column represents the number of cubic feet in whole numbers and decimal parts, discharged per second, and each alternate column thereafter, represents the theoretical amount of horse power due to the quantity of water issued. The diameters of the different nozzles are given in the first horizontal line at the top.

The orifices or nozzles are presumed to be at the end of a large and short hose or piping, and that the approach or entrance of the water to the nozzle, is without any considerable velocity, and guided by a properly shaped and contracted conductor ; having what is known as the proper curve or contracted vein. Such a nozzle discharges the largest quantity of water possible, equalling almost the full or theoretical amount that would be discharged, when left to flow freely and governed by the laws of gravitation.

In ordinary orifices or openings a considerable less quantity of water will be discharged per second, as the flow of the water to the orifice is not conducted by a proper contracted entrance. A jet of water will be found contracted on the outside of the issue, and at some distance from the opening ; consequently the quantity of water discharged will not be equivalent to that which would pass through the actual opening, but a quantity that would pass through an opening the size of the flow of water, at the narrowest place of the jet or stream or where the greatest contraction occurs. This usually ranges from 65 to 95 per cent of the theoretical discharge.

In this table there is no estimate made for the loss of head or velocity by friction. This loss will depend altogether on the size of pipe conducting the water to the nozzle, and on the velocity in the pipe, as will be seen in other tables elsewhere given ; therefore the table cannot be taken literally for the quantity of water that is usually actually discharged under ordinary circumstances. The horse power given for each quantity discharged, is also the theoretical power aud not that which is actually given ; as when applied to the water wheels, pumps, motors, etc., there is a considerable loss through the imperfect application and friction. The table represents a considerable greater quantity than is usually discharged, except under the peculiarly favorable circumstances mentioned in the beginning of article ; and of course the amount of power tabled is in excess of what can be realized in ordinary cases, because of the greater issue of water, and the fact that the estimate is for the full theoretical amount of power, without any calculation for losses of any kind.

100 Barrel Roller Mill.

PRESTON, MINN., March 30, 1885.

Messrs. James Leffel & Co., Springfield, O.:

DEAR SIRS—We are using one of your 50 inch Special Wheels in our grist mill. It was put in November 1877 and has never been taken up. It furnishes power for our 100 barrel roller mill, under an eight foot head, and has not cost us to exceed ten dollars for repairs for the seven years. We also have a 44 inch Special bought of you in the fall of 1884 with which we are running a feed mill, 2 run stones and other machinery, and have power to spare. We consider them the best wheels that we have used.

Yours truly, CONKEY BROS.

FLOW OF WATER PER SECOND THROUGH CLEAN PIPES.

Fall per Mile in Feet.	Fall per Rod in Inches.	BORE OF PIPES AND CUBIC FEET DISCHARGED.														
		8 in. cu. ft.	10 in. cu. ft.	11 in. cu. ft.	12 in. cu. ft.	14 in. cu. ft.	16 in. cu. ft.	18 in. cu. ft.	20 in. cu. ft.	22 in. cu. ft.	24 in. cu. ft.	27 in. cu. ft.	30 in cu. ft.	33 in. cu. ft.	36 in. cu. ft.	40 in. cu. ft.
2.64	.10											8.27	10.24	12.92	16.35	22.08
3.70	.14						2.25	3.10	4.07	5.25	6.64	9.09	11.90	15.14	19.76	26.27
4.75	.18					1.83	2.59	3.49	4.68	6.01	7.56	10.26	13.48	17.58	22.30	29.80
5.28	.20				1.26	1.91	2.72	3.66	4.92	6.32	7.95	10.74	14.21	18.74	23.47	31.46
6.33	.24		.87	1.12	1.40	2.11	3.02	4.06	5.40	6.94	8.75	11.93	15.81	20.28	26.12	34.68
7.39	.28		.96	1.22	1.48	2.27	3.28	4.40	5.82	7.51	9.47	12.96	17.18	22.20	28.24	37.57
8.44	.31	.57	1.04	1.32	1.63	2.44	3.49	4.75	6.27	8.05	10.13	13.98	18.58	23.76	30.29	40.54
9.50	.35	.61	1.11	1.39	1.72	2.59	3.69	5.03	6.65	8.55	10.77	14.81	19.66	25.22	32.48	43.07
10.56	.39	.63	1.19	1.49	1.82	2.72	3.92	5.30	7.05	9.07	11.43	15.63	20.79	26.94	34.49	45.20
11.62	.43	.66	1.26	1.58	1.94	2.88	4.12	5.63	7.42	8.55	12.05	16.44	21.80	28.27	36.15	48.12
12.67	.47	.70	1.32	1.65	2.02	3.02	4.32	5.87	7.79	10.01	12.61	17.23	22.83	29.02	37.74	50.48
13.72	.51	.73	1.37	1.72	2.11	3.15	4.51	6.18	8.14	10.48	13.23	18.01	23.93	31.06	39.40	52.67
14.78	.55	.76	1.42	1.78	2.20	3.29	4.68	6.38	8.48	10.91	13.79	18.75	24.86	32.28	40.86	55.04
15.84	.59	.82	1.47	1.85	2.29	3.42	4.87	6.64	8.77	11.29	14.25	18.50	25.87	33.62	42.28	56.33
18.48	.68	.87	1.58	1.99	2.46	3.62	5.31	7.17	9.49	12.25	15.50	21.13	27.96	36.17	45.95	61.09
21.12	.79	.93	1.68	2.13	2.66	3.99	5.67	7.65	10.16	13.12	16.62	22.62	29.84	38.57	48.83	65.41
26.40	.99	1.04	1.86	2.39	3.02	4.46	6.39	8.66	11.43	14.78	18.71	25.34	33.55	43.12	54.89	73.09
31.68	1.18	1.15	2.05	2.63	3.31	4.91	7.02	9.54	12.59	16.20	20.42	27.74	36.79	47.40	59.95	80.32
36.96	1.38	1.26	2.22	2.85	3.60	5.37	7.66	10.33	13.66	17.53	22.05	29.96	39.66	51.35	65.17	86.70
42.24	1.58	1.34	2.38	3.06	3.85	5.77	8.16	11.09	14.66	18.78	23.61	31.99	42.39	54.91	69.80	92.58
47.52	1.78	1.42	2.51	3.23	4.07	6.11	8.64	11.71	15.54	19.93	25.07	33.97	45.23	58.20	74.33	98.00
52.80	1.98	1.49	2.66	3.41	4.30	6.44	9.10	12.37	16.47	21.06	26.42	35.89	47.71	61.62	78.46	103.99
63.36	2.37	1.64	2.93	3.76	4.72	7.00	9.95	13.65	17.99	23.07	29.03	39.76	52.92	68.00	82.84	
73.92	2.77	1.78	3.21	4.01	5.09	7.60	10.87	14.75	19.49	24.68	31.49	43.22	57.65	73.95		
84.48	3.16	1.91	3.45	4.39	5.48	8.17	11.63	15.84	21.03	26.97	33.90	46.57				
95.04	3.56	2.03	3.67	4.67	5.83	8.93	12.43	16.90	22.45	29.70	36.18	48.06				
105.60	3.96	2.15	3.85	5.25	6.16	9.26	13.14	17.85	23.56	31.15	38.45					

See next page for explanation.

Explanation of Table on Preceding Page.

The table on the foregoing page has been specially arranged by us from formula and parts of tables by Randall; and gives the quantity of water in cubic feet discharged per second, flowing through smooth, iron pipes, the length of each of which is estimated at one thousand times the diameter. It is understood, as has already been explained in our tables on pages 89, 90 and 91, that the length of pipe affords a resistance to the flow, according to the quantity of water passing, or the velocity with which it is discharging. For any length of pipe in this table of less or more than one thousand diameters, an additional increase or decrease of flow, the loss or gain of resistance may be approximately estimated from our tables on pages just alluded to.

It must be remembered that this table is given for clean, smooth piping. If it is ordinarily rough the flow will be about twelve per cent. less than the quantity given. In case the pipes are very rough, a loss of nearly twenty-five per cent. would have to be deducted from the estimate contained in the table. Of course if bends or angles are introduced, these will materially affect the discharge also, depending on the number and the abruptness of the bend or angle. If they become actually necessary, the bend should be of the longest possible radius, and all narrow passages or contracted portions of the pipe should be avoided. It would be difficult to attempt to give any formula, or general rule to answer all the cases that might occur in connection with these angles or bends, which may arise from undulations in the profile of the pipe, or by horizontal deviations from straight lines.

It is hardly necessary to give an example for the quantity of water that may be discharged in any particular case, as the table will be sufficiently well understood upon a mere examination to enable any one to estimate correctly. The first horizontal line represents the bore of the different sizes of pipe in inches; and the first perpendicular or vertical column represents the fall per mile in feet and hundredths of a foot; while the second upright column the fall in decimals of an inch per rod. All the perpendicular columns following the two already described, represent the number of cubic feet discharged by each pipe, under each head in feet and hundredths of a foot per second.

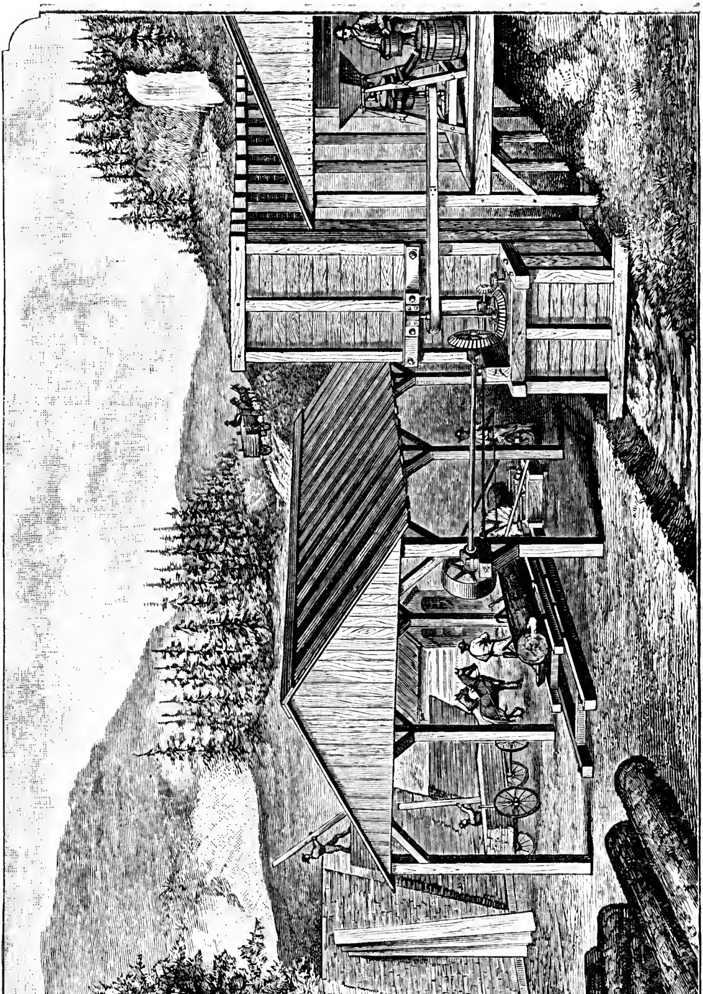
It is hoped that the table may be of some practical service to our correspondents and others advising with us.

Saw and Gin Mill.

De Soto, Miss., April 6th, 1885.

Messrs. James Leffel & Co.:

Gents—We are using a 40 inch Turbine Wheel with entire satisfaction. We run a fifty inch saw and cut from two to four thousand feet of lumber per day with 8 feet head of water. We also run a fifty saw Gin with about one-fourth gate; gin from four to six bales per day. Very respectfully, R. P. McLEOD & BRO.



Description of Frontier Mill.

We present on the preceding page an illustration of a frontier mill, combining in one view a saw-mill and grist-mill both of simple construction and convenient arrangement. Either may be run separately or both at the same time. The cut is sufficient in detail to give a correct idea of the entire affair.

Such a mill can be easily and very cheaply constructed ; one water wheel answering both purposes ; requiring only one penstock, and being capable of being detached from either at leisure. The wheel may be of medium size, ranging perhaps from 20 to 40 inches diameter, with gearing, shafting and pulleys arranged and adapted to the size and for the purpose intended, this general plan or design answering for either of the sizes of wheel named.

We can recommend this method in instances even where quite a permanent and durable arrangement is desired, although it is perhaps more applicable to frontier use. Both of the structures protecting the different kinds of mills may be made even more temporarily than the illustration exhibits, should it be desired to expend the least amount possible for its successful operation. The grist and saw mills may both be of portable character, which will still further enable the easy and rapid completion of such an enterprise.

Ten Wheels, all Satisfactory whether at Whole or Partial Gate.

James Leffel & Co., Springfield, Ohio:

MENOMONIE, WIS.. April 6, 1885.

GENTLEMEN—We have in all 10 of your wheels in our mills, some of which have been in use so long that we cannot now say when they were bought. They are one and all doing excellent work as attested by the amount of machinery they drive, as follows:

One 66 inch Leffel in our water power saw mill, 11 ft. head, running 1 Double Rotary, one 4 Saw Edger, one 6 Saw Edger, 5 Cut Off Saws, 1 Picket Mill and 1 Slab Grinder—the latter a load of itself for most any good wheel.

One 26½ inch Leffel, 11 ft. head, in Machine Shop, running 4 Iron Turning Lathes, 1 Iron Planer, 1 Drill, 1 Bolt and Nut Cutter, 2 Wood Turning Lathes, 1 Grindstone and Jig Saw.

One 52 inch Leffel, 16 ft. head, runs a Gang of 26 Saws.

One 52 inch Leffel, 16 ft. head, runs 1 Single Rotary Saw, one Edger, 3 Cut Offs 1 Bolter, 1 Slab Chain and 1 Cant Carrier.

One 35 inch Leffel under 16 ft. head, runs 1 Lath Mill complete, 1 Log Haul and 1 Slab Chain.

One 35 inch Leffel, 16 ft. head, runs 4 Shingle Jointers, 2 Cut Offs, Turning Lathe and Grindstone and an Electric Light Dynamo requiring 20 Horse Power.

One 40 inch Leffel, under 16 ft. head, running 3 Electric Light Dynamo's requiring 50 Horse Power.

Three Special 44 inch Leffels bought in 1881 and put in our Flour Mill at Chetek, drive 3 run of 48 inch burrs, 1 pair Steven's rolls, 1 double porcelain roll with cleaners dusters, purifiers, bolts, cockle separator, and all the machinery of a first class flouring mill. These latter have given satis factory results under 4 ft. head as also under 11 ft. We consider the special Leffel the best wheel we know of for a flouring mill running under a varying head of water. All the wheels have given us entire satisfaction whether used at full or partial gate. Yours truly,

The KNAPP STOUT & CO., COMPANY.

H. E. KNAPP, Asst. Secy.

Special Notice to Those Writing About Wheels.

We are constantly in receipt of letters asking about the size of wheel to do a certain amount of work. Some merely say, "I have so many feet head"—not a word about the quantity of water; some say: "The stream will furnish so many cubic feet of water per minute"—not a word about the head; and some give neither head nor quantity of water; others ask, "What size wheel shall I use to grind so many bushels per hour?" This may appear strange, but it is a fact; hence we are so particular in stating what is required to be known. If attention is given to this article as to ascertaining supply and quantity of water, and the questions contained on these pages are answered carefully, much time and trouble will be saved and many disappointments prevented.

In ordering a wheel or asking for information, please give the following data:

QUESTION 1. What is the head of water when at rest; or the vertical distance from surface of head-water to surface of tail-water?

QUESTION 2. If the stream is small, what quantity of water can be relied upon; that is, what depth and width of spill is there over the weir board as described and required in our article on measurement of water over weirs, on page 4 to 11; or if an overshot has been used, state how wide and how much the gate was raised to let the water on it, and particularly how deep the water was above the gate opening in the forebay?

QUESTION 3. If the stream is large, state whether a creek or river, and if possible give us a measurement according to our instructions for "large open streams," described on page 9.

QUESTION 4. What size and kind of wheel, if any, is at present or has been running, and how many square inches opening is there in the wheel, if turbine or reaction wheel; and how many hours out of the twenty-four will the stream afford sufficient water to supply it?

QUESTION 5. What kind of machinery do you wish to run? stating all the particulars you can.

QUESTION 6. If a corn or wheat mill, state whether an old or new mill, size and number of burrs, how many bushels each one is grinding at present, and how much do you wish to grind on each; state how many are to be running at one time, whether one, two, three or more.

QUESTION 7. If a circular saw, state particularly the size, and what speed it has if an old mill, or what speed desired if a new mill, and particularly what kind of timber is to be sawed and the amount per day.

QUESTION 8. If a sash or vertical saw, state speed or number of strokes it makes or is desired to make, and the length of stroke, what kind of timber you intend cutting, and particularly what amount of feet, inch measure, you intend cutting in twelve hours.

QUESTION 9. If a woolen mill, give the number of sets of ma

chinery, whether light or heavy, and kind of goods made; state whether new or old mill, kind and size of wheel in use.

QUESTION 10. If a cotton mill, give the number of spindles, also of the looms, and the class of goods made, and whether old or new machinery.

QUESTION 11. If a rolling mill, give size of rolls, number of revolutions per minute, and size of iron to be rolled.

QUESTION 12. If trip hammers give number of hammers and weight of each, and numberof strokes per minute.

QUESTION 13. What is the spead of your main line of shafting, and is it upright or horizontal?

QUESTION 14. If the power is to be taken off *above* the level of head-water, give us the distance from level of head-water to center of horizontal power shaft, if a saw, woolen or cotton mill; and what the distance from said level of head-water to a level of the bed-stones, if a grist-mill.

QUESTION 15. If the power is to be taken off *below* the level of head-water (as our decked flume plate illustrates, page 87,) state the distance from center of horizontal power shaft *below the head-water* (or the distance above tail-water) when at rest.

QUESTION 16. When there are main and connecting gears, always state whether spur or bevel, number of cogs, pitch of cogs, width of face of drivers and pinions.

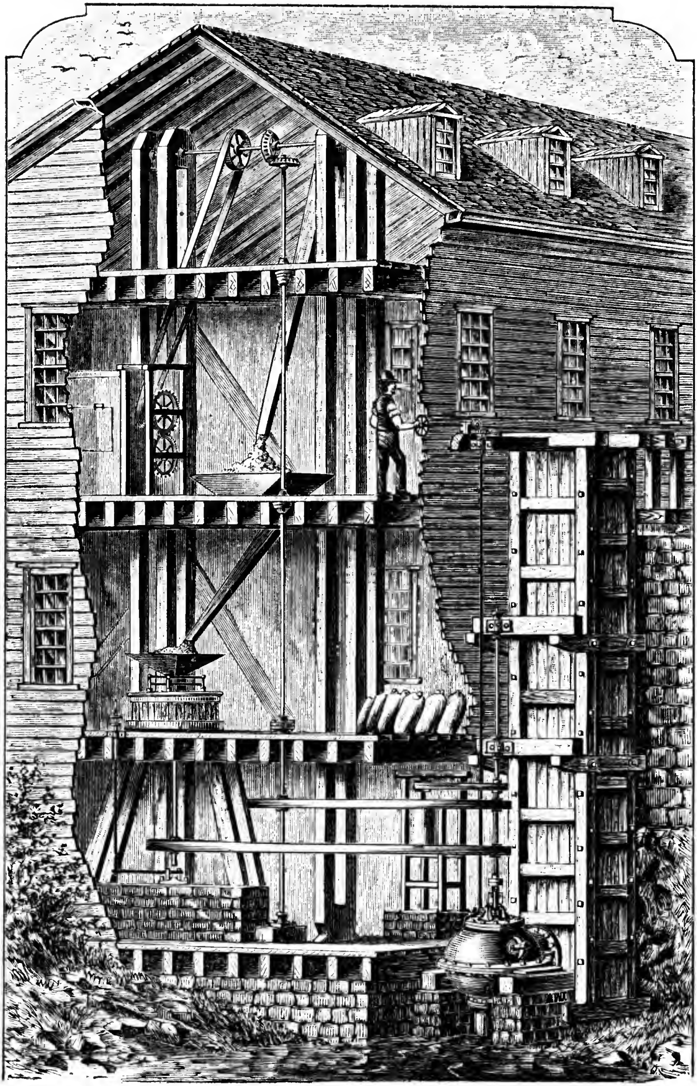
NOTE.—If it is impossible or difficult to obtain any of the foregoing data, with even a moderate degree of accuracy, we would like any other information that may be in some manner relevant to the subject. With a statement of some kind it may be possible for us to offer some advice or give an idea of the requirements in the way of a wheel as to size, price, etc. At all events, we shall be pleased to receive any inquiries concerning the wheel, with such knowledge of the circumstances in the case as correspondent may have at his command: we will then answer all in as satisfactory a manner as the nature of the case and the amount of information will admit.

In ordering wheels, don't fail to state which way they must run, With or Against the sun, Right or Left handed, and observe shipping instructions on page 126. For Price List of James Leffel's Wheels see page 49, of this pamphlet.

PULASKI, TENN., March 27, 1885.

DEAR SIRS—It is seldom the case that we are asked our opinion of an article that gives us real pleasure in commending, but it is with the sincerest pleasure that we recommend Leffel's Water Wheels. We are now using two of them and cannot speak too highly of them. With a 50 inch Special Wheel we are running three burrs with all the attachments added of a merchant mill. We are also running our cotton mill, which uses 35 horse power to drive it, with a 60 inch Special. They stand side by side, under a 7 foot head, and are not at all affected by stopping one of them. They run so steadily that we do not use any governors on them. We replaced a 62 inch American with the 50 inch Leffel and find it gives us more power. We appreciate your instructions in regard to not over-estimating the Leffel, and assure you that if they did not do the work as we state, we certainly would not say anything in their behalf, but we would condemn them. They are all we want in a water wheel.

Yours truly, J. G. & N. SMITHSON, Propr's.



Explanation of Plate on Foregoing Page.

On the foregoing page we have presented a cut showing an extremely simple manner in which our water wheel can be attached to the machinery of a Flour Mill. This cut shows a mill of the same capacity and under the same fall as an overshot mill which we will describe in this article, in order to enable us to compare the different methods of applying the two kinds of wheels, showing many advantages gained by the use of our wheel over the overshot, particularly on small streams and high falls ; and to more clearly show this we ask a careful comparison of the arrangement shown in this cut with that which we will describe of the overshot mill, having taken the same fall and the same size stream in both instances.

On page 46 and in the explanation following we endeavor to show also some of the advantages of the Turbine in its location over the overshot. That illustration with the one we now propose describing shows the infinitely superior arrangement of machinery which can be secured by our wheel. For the purpose of comparison in this instance, we have selected an overshot wheel of 22 feet diameter and 3 feet face, used for the purpose of propelling a small flouring mill under 24 feet head and fall ; being of a size suited to small streams of water. It is well known that an overshot of these dimensions, well constructed and in the lightest manner possible, is of enormous weight ; which is greatly increased by the weight of the water in the buckets ; and it is evident that this immense weight will cause quite a loss of power from the friction of the bearings at the ends of the water wheel shaft. In order to transmit the power of the overshot wheel, a large bevel wheel of about 12 feet diameter is placed on the water wheel shaft, which works in a small pinion wheel or pinion on a large upright shaft usually passing up through the mill and to which the balance of the machinery is attached. A large spur wheel of 9 feet diameter is placed on the upright shaft, this spur-wheel working into the pinion on the spindle of the burr. As the motion of the wheel is slow, a bevel-wheel of small diameter, a large spur-wheel and a small pinion must be used in order to get up the proper motion of the burrs ; and as the strain on this gearing is enormous by reason of the slow motion of the wheel, all the parts must be heavy and cumbersome to sustain the force applied. The upright must be at least eight inches in diameter as its motion is only about twenty revolutions per minute. Not only does this slow motion require massive pit-gearing, but in order to run the machinery at its proper speed the shaft H should be at least 4 inches diameter ; for it is to be observed that the power necessary to run the smutter must be transmitted through heavy gears and large pulleys. The many objections to the whole arrangement may be briefly stated to be as follows : The great expense involved in the construction, as it requires several tons of iron to give proper strength to shafts and gearing ; the great loss of power from friction arising from heavy and complicated machinery ; the points of friction are at the two journals of water wheel ; the master-

wheel and bevel, the spur-wheel and pinion, the Smutter gears with the bearings of the shaft, and the bevels, all of which move with a sluggish motion, are subjected to an enormous pressure, which must necessarily consume a vast amount of power.

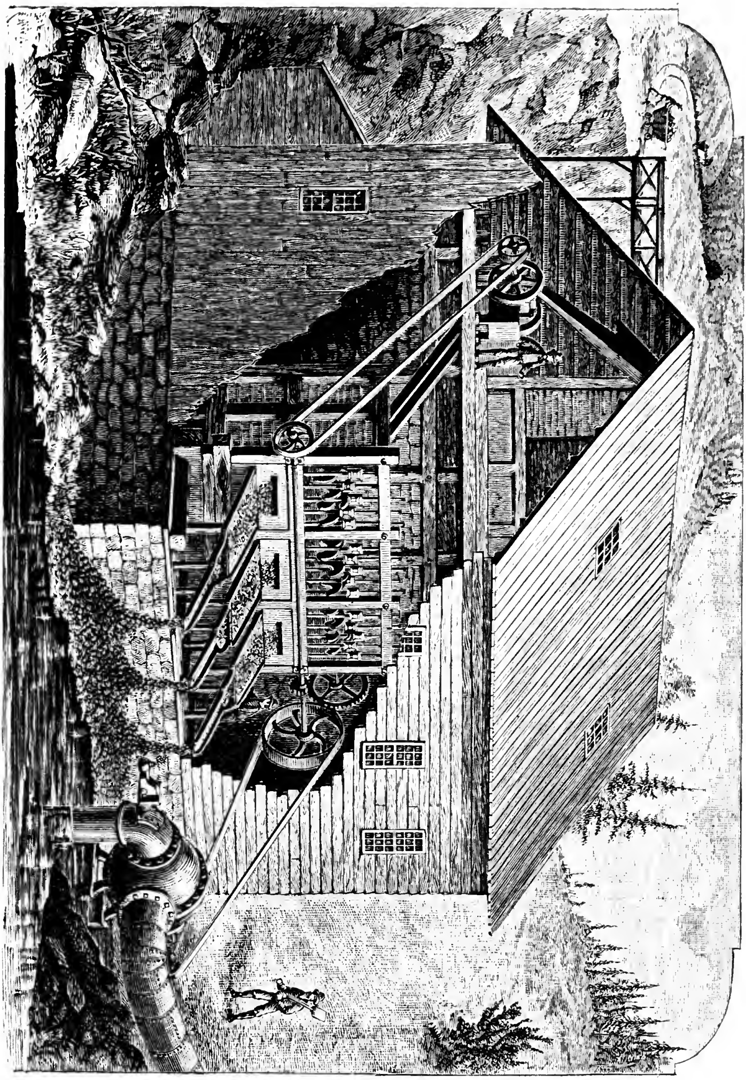
Instead of using a 22 feet overshot we would use one of our wheels $11\frac{1}{2}$ inches in diameter, which will give even more power than the 22 feet overshot wheel. The shaft of the overshot wheel must be at least two feet in diameter of wood, and at least ten inches diameter of iron. The shaft on our Turbine wheel need not exceed $1\frac{3}{4}$ inches in diameter. Instead of the massive master–wheel, bevel-pinion and spur-wheel which together weigh several thousand pounds in the overshot arrangment, we would use only a ten-inch pulley weighing only about thirty pounds on our Turbine, and run a belt direct to the pulley on the spindle of the burr. The upright shaft used with the overshot must be from four to eight inches diameter, in order to sustain the heavy strain resulting from a slow motion; while the same shaft when our wheel is used, need not exceed $1\frac{1}{2}$ inches in diameter, as we would give it a quick motion and reduce the speed upon the reels and other machinery; while from the slow speed of the overshot machinery a constant increase from a slow to faster speed is required; with our wheel the reverse is the case. It will be observed that in order to obtain the proper speed for the smutter and separator, a large spur-wheel and pinion, and pulley, are necessary where an overshot wheel is used; but none of this gearing is necessary where our wheel is substituted, as it will make nearly six hundred revolutions per minute. The pulley on the water wheel shaft need be but slightly larger than the pulley on the smutter, which is usually about 8 inches diameter.

It must be apparent to all, that by the use of our wheel not only is there much saved in the cost of machinery, but a great gain of power is effected from the simplicity of the arrangement and such direct communication of the power to the work to be done. In the case of an overshot, the power is communicated through a vast amount of heavy gearing weighing thousands of pounds, and consequently laboring under the disadvantages of a necessary increase of motion; while the amount of machinery required by our wheel consists of only a short shaft and three pulleys, altogether weighing but little more than one hundred pounds, and besides, having a motion of over six hundred revolutions per minute, possesses the great advantage of a reduction of motion on the burrs.

But it is needless for us to further point out the many advantages our wheel possesses over an overshot wheel, as an examination of the two cuts we have given, and the explanation in connection with the different arrangements, cannot fail to convince even the most skeptical.

Gold Mill.

The illustration on the opposite page, exhibits the usual application of our new Improved Vertical Mining Wheel to a Gold Mill; one of



the simplest construction. This new Mining wheel was more especially designed for mining purposes than for any other particular use; although it has in a number of instances been applied to Saw-Mills, Paper-Mills and other manufacturing establishments, in which it has been found equally well adapted. An illustration of a Saw-Mill driven in this manner will be found in another part of the book, and a large Paper-Mill in still another illustration.

The mill illustrated in the cut herewith, is one of a class of mills for the reduction of precious metals in the mining regions similar somewhat in operation and construction. This mill is what is usually termed a Free Milling Gold Mill, without the complicated machinery that is generally required for the reduction of various gold and silver ores. The application of our mining wheel is similar however, whether it be applied to a Gold or Silver Mill, a Concentrator, or Reduction works; all of which are usually driven from a primary horizontal shaft. From this main shaft within the works, other machinery is driven, depending upon the quality of the ores and the necessary adaptation of the works to their proper treatment. Our cut illustrates the simplest kind of mill; requiring only an ore crusher in the upper portion of the building, and any suitable number of stamps in the lower part of the building, which constitutes all of the running or operating machinery.

This cut illustrates a fifteen stamp gold mill. The ore crusher in the upper portion of the building reduces the ore to a regular and even size, and from this crusher it is run into bins or chutes conveying the ore to the stamps. These stamps operate in mortars where the quartz or ore is pulverized by the action or reciprocating motion of the stamps. The stamps usually range from 150 to 850 pounds each, and are raised perpendicularly to a hight of eight to fourteen inches, making sixty to a hundred drops a minute, and requiring usually from one to two horse power per stamp, having a capacity of one to three tons per day of 24 hours, depending on the kind and quality of the ores. A small but constant supply of water is admitted to the mortar in which the ore is being crushed; and when it is reduced to a certain fineness, is washed through screens just behind the openings shown in the illustration. This crushed mass falls upon and is washed over inclined amalgamated and silvered copper plates, as the illustration exhibits. From these plates the gold is afterwards gathered.

The application of our Vertical Mining wheel to this class of mills avoids the necessity of gearing, in making the first transmission. This is desirable on account of the high speeds that are usually necessary in small wheels, applied to the high falls and small quantities of water, which are so generally found in the mining sections of our country. It is only necessary to place the wheel on a good firm foundation, with the shaft level, and parallel to the main horizontal shaft within the works. Then by connecting a belt direct from the small pulley on the water wheel shaft, to the large one on the first main counter

shaft, the power is thus easily and simply applied. It will be observed in the illustration that a short draft tube extends down from the discharge pipe, touching the tail water. The use of this short draft tube should invariably be observed, wherever it is desired to obtain the greatest amount of head pressure. Of course underneath the end of the tube an ample and sufficient discharge pit, or space, should be excavated, so that the water will not be retarded in its flow, thus giving it a free and easy escape, avoiding a reaction on the wheel and a consequent loss of power, as would be the case if the space were not sufficient. A small part of the head pipe is also shown. This could extend to any practical distance and hight. We have a large number of these wheels in operation throughout the entire mining region, driving mining machinery of every description, and it has proven itself perfectly adapted and entirely successful.

There are Over 12,000 Leffel Wheels in Use, Giving Over 500,000 Horse Power.

Although we regard the fact that our wheels have given satisfaction, under the endless variety of circumstances under which they are placed, as undoubted evidence of their excellence and superiority, yet we consider the immense number that have been put in operation as the strongest proof of their great merits, and of their fully meeting the great necessity of manufacturers depending upon water as a motor. Such has been the complete satisfaction our Wheels have given, and so great has been the demand for them, that we have now in *successful operation Twelve Thousand Wheels, yielding in the aggregate the immense power of over Five Hundred and Fifty Thousand Horse Power.* We think no other evidence than this is needed to convince any uprejudiced person of the unequaled merits of our wheel. Many hundreds of letters highly commending the wheel can by produced, if that kind of evidence is regarded of more value.

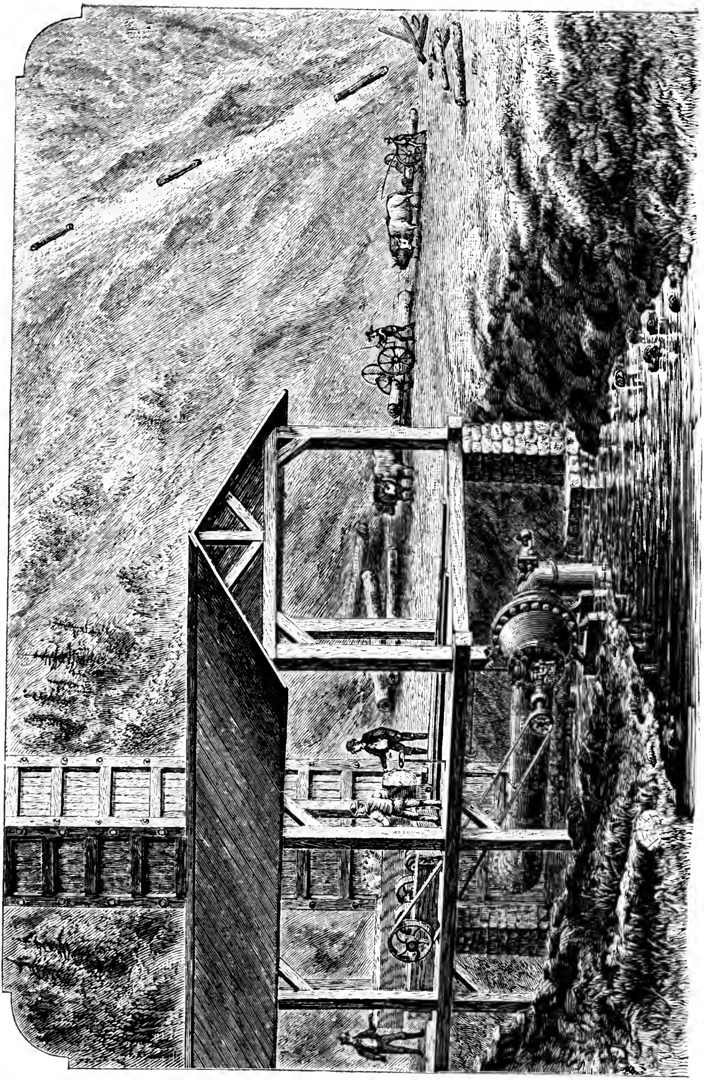
In every Particular give better Results and better Satisfaction.

ROCKFORD, ILLS., April 8, 1885.

Messrs. James Leffel & Co., Springfield, Ohio:

GENTLEMEN—We wish to say, that we have been using water wheels of all kinds and description, for upwards of forty years and we have at present in use three of your improved double Turbine, well as four others of first class make, and without any hesitation we can truly say that your wheels in each and every particular, give far better results and better satisfaction than any we have heretofore used, and inasmuch as our mills require a steady and uniform motion we use them with a regulator attached, and whether under a full or part gate we are able to obtain as even and uniform speed as if we were running by steam, and further will state that while in our experience we have found some make of wheels to give a fair result under a high head of water, we must say that under a low, or medium head, no wheel equals them that has come to our notice. At this present time the water in our dam is exceedingly high, but as soon as it reaches a point that will enable us to place another wheel we shall want one, and while some wheels are being offered at a much lower price than yours, we shall take yours in preference feeling that it is greatly for our interest to do so. Yours respectfully,

GRAHAM'S COTTON MILLS.
Per FREEMAN GRAHAM Jr. Treas



Saw Mill Driven by Mining Wheel.

The illustration on the opposite page exhibits, as is clearly seen, a rather new and somewhat novel method of propelling a saw mill. It is the application of one of our Mining Wheels having a horizontal shaft and the wheel running vertically. Such an arrangement is extremely simple and is conveniently applied. The necessity of gearing, which is almost universally employed where larger wheels with upright shafts are used, is entirely obviated by the substitution of this style of wheel in place of the ordinary make. By placing the wheel some distance away from the saw, necessary .o obtain a reasonable length of belt, it may be situated either below or above the floor; usually below the floor is most convenient, as it does not occupy the milling flour space. When it is placed on the mill floor, it is necessary to use a long draft tube, extending down until it touches the surface of the water; this being necessary in all cases, and at whatever distance the foundation of the wheel may be above the level of the tail water.

This illustration shows a wooden penstock of rather more than usual hight; and extending above the view obtained in the picture, of course connecting by a horizontal part not shown, to the dam or race, and having a head pipe which conducts the water to the wheel, attached to the bottom of penstock and running horizontally, but with an elbow at the penstock. The use of the wooden penstock or bulkhead, may be avoided by the application of a larger iron head pipe, running from the wheel at any inclination or distance, until it reaches the dam or bulkhead from which the supply of water is obtained. This method for driving Saw Mills is more frequently applied in instances, where the head is of considerable hight, and the wheel required of small dimensions. The high speed is quickly and simply reduced, by connecting from the small pulley on the water wheel shaft, direct to a pully of considerable size on the saw mandrel.

The simplicity of the arrangement commends itself to all parties desiring an efficient, easily managed and well regulated establishment. There is no question as to the excellence of this design for Saw Mills; providing parties desire the least complicated method of applying the power. In different parts of the pamphlet, several letters will be found from parties making use of this style of mill, and they give their unqualified approbation as to the satisfaction it affords them. No one need hesitate adopting the method.

Cotton Mills.

A fact worthy of particular notice is the large number of the Leffel Wheels which have been sold in the last few years, in the New England States. A very significant feature of the case, also, is the extent to which this wheel has been adopted by Cotton Mill owners throughout that region, who investigate as to the qualities of a wheel

more thoroughly, or with whom good, steady, reliable power is a more vital consideration, than is the case with proprietors of other mills. Nor is there any class that more strongly objects to trying experiments in water wheels. They demand, in buying a wheel, that it shall have been proved to possess the greatest practical value; and should they entertain the slightest suspicion that the wheel is not first-class, they will have nothing to do with it. We could give a very large list of names of parties using the wheel, giving in the aggregate 30,000 horse power, in such mills, not only in this country but in foreign countries also.

That there is a valid foundation for this exacting care in the selection of wheels for cotton mills is manifest from the fact that the nature of the business is such as to require an enormous amount of power; as an example of which we have in one mill of this class, wheels affording a total of 1,700 horse power. It is also a very essential point in such establishments that the power should be easily controlled and regulated, its available effect being influenced to a marked extent by the steadiness and facility with which it is managed. It is for these reasons that the Leffel Wheel has attained such extensive popularity among the cotton mills of New England (as well as other portions of the country); it having been proved by its practical operation for a long period, and under the most trying conditions, to possess unquestionable superiority in amount and uniformity of power and the ease with which it is controlled.

It is important in putting in the wheel, that the work should be done in the most substantial manner. In the plate on page 50 is shown the manner in which the Leffel wheel is usually put in, in the large cotton mills of New England. In the plate only iron and stone penstocks are shown, but wooden penstocks are also used to some extent.

20 Inch Mining Wheel in Saw Mill.

MEADOW CREEK, MADISON CO., MONTANO.

Messrs. James Leffel & Co.:

DEAR SIRS—We have two of your wheels in operation, one fifteen inches under thirty-five feet head, running a fifty-six inch Saw, Pony Planer, and Shingle Machine. Also twenty inch Mining wheel under twenty-nine feet head, running 52 inch Saw, Planer and Shingle Machine. The wheels do their work in first class manner, without trouble or tinkering giving perfect satisfaction as to power and capacity. We are working the hardest, and toughest Pine, in the world and for that reason the amount of work we are doing would be no criterion for other localities where heavier feed can be used. Respectfully yours, HAWKINS & HIGBY.

DEL RIO, TEXAS, April 23, 1885.

Messrs. James Leffel & Co.:

GENTLEMEN—Your favor of the 26th inst., at hand. In reply we take great pleasure in saying the New Improved Special 50 inch wheel which we have now had in use some ten months gives perfect satisfaction. Our working head is 5½ feet. With ⅓ gate we run all the machinery (both gass and water pumps) of an Ice Machine which formerly took an 8 Horse Power Engine. With half gate we run in addition to Ice Machine a set of 20 inch burrs. We have been put to no outlay for repairs and say that it does more than you claimed it to do and that we are well pleased with it. Yours respectfully, DEL RIO ICE CO.

An Interesting Business Experience.

BUFFALO VALLEY, PUTNAM CO., TENN., Dec. 12th, 1882.

JAMES LEFFEL & CO.

GENTLEMEN—In 1874 I was advised to buy and rebuild an old mill that had one corn run in it and ground 4 bushels per hour, and which was such hard property that it passed from hand to hand like an old blind horse.

After investigation I concluded to put in a 30½ inch Regular Leffel Wheel as a motor, and attach a 36 inch corn run and a 36 inch wheat run with bolts, elevators, smutter and all necessary machinery for a custom mill. My head was only 8 feet 4 inches, and through the summer the water was scant.

This was a hardy venture for a man with $500 capital, which was all I had of my own. The old-timers predicted a disastrous failure. You may judge of my surprise and joy when the little wheel walked out with my burrs and ground 24 bushels of corn in one hour. So unexpectedly economical was my wheel that I found that out of over abundance of caution I had undersized my stream. I had hardly enough power to drive both run up to speed which was partly owing to insufficient size of wheel pit.

After my mill had put me on my feet I replaced my original wheel with a 30½ Special, which gave enough added power for all purposes without changing the speed. As I have told you I only do custom work and I do not care anything about its capacity so long as it does all the work which is brought to it, which it easily does. It has furnished my family, which is a large one, with all my bread and meat, and fed my milk cows and netted me over a thousand dollars a year.

In the summer time when water is scant I often grind my head down to 3 feet, and in the winter I have ground with the water within 18 inches of the top of the dam, or with the wheel under nearly 7 feet of back water. When I grind wheat alone with a full dam I only use ½ gate to grind the capacity of my bolt, and if I do not get nearly or quite half the power of the wheel I cannot discover it.

One of the incidents with my wheel is that a 2 by 4 inch seasoned hickory stick, got out for cog timber, was dropped into the penstock and drawn into the wheel while running with one set of burrs under a full head. The wheel was stopped instantaneously while the burrs went on, crushing the teeth out of the spur wheel. I drew off the water and went down to the wheel with a heavy heart. On taking out the stick I found that the bucket had bit into it fully an inch deep clear across the four inch face and the wheel was unharmed, except a cracked gate which was replaced for a trifling sum. Last winter twenty feet of my dam foundation and all was swept out and I ground ten bushels before the creek ran down. Under all the varying conditions and severe tests this wheel has been subjected to it has been a continual surprise and satisfaction to me, and I cannot believe I could change it for any other wheel without loss.

Yours truly, WADE JONES.

A Roller Flouring Mill.

The cut on the opposite page, illustrates a general arrangement, and application of water power to Roller Flouring Mills. In the illustration only a portion of the interior of the mill is shown. Four of the Roller Mills may be seen, and in a mill of ordinary capacity usually two or three others are employed. In fact a mill of almost any capacity can be built upon this general plan, by extending the building any convenient length, in which case it would be necessary only to extend the main driving shaft in the basement, to a corresponding distance. The upper portion of the building shows the machinery, usually employed in dressing the products, as they are gradually reduced, and the extreme upper portion of the building for cleaning the grain before reduction commences. The Elevators, Spouts, Hoppers etc., are also to be observed. It is to be presumed of course, that any other convenient arrangement of these different machines, in the upper portion of the mill, can be adopted ; but the general plan of driving from below is in most instances conformed to. Sometimes even the second story is partly occupied by the Roller mills in accomplishing part of the reduction.

The application of the water wheel is simple. In this instance, a high penstock with a decking is shown, and a Leffel wheel of ordinary size, placed in the elbow of decking ; and by means of the usual pair of Bevel Gears the power is transmitted to a horizontal shaft, to which the belts are attached, leading to the roller mills, and to any other machinery that may be located on the first or principal floor. In case larger water wheels are used upon lower heads of water, the decking or high penstock, may be dispensed with, and the gearing placed immediately on top of the penstock, and still sufficient space obtained in the basement in which to locate the main power or horizontal shaft. In placing this shaft it is best to have a bearing near each main belt for transmitting the power. Further details and description, it is presumed are unnecessary. The illustration no doubt clearly conveys the general idea in carrying out such an enterprise.

Runs Roller Mill in place of Overshot.

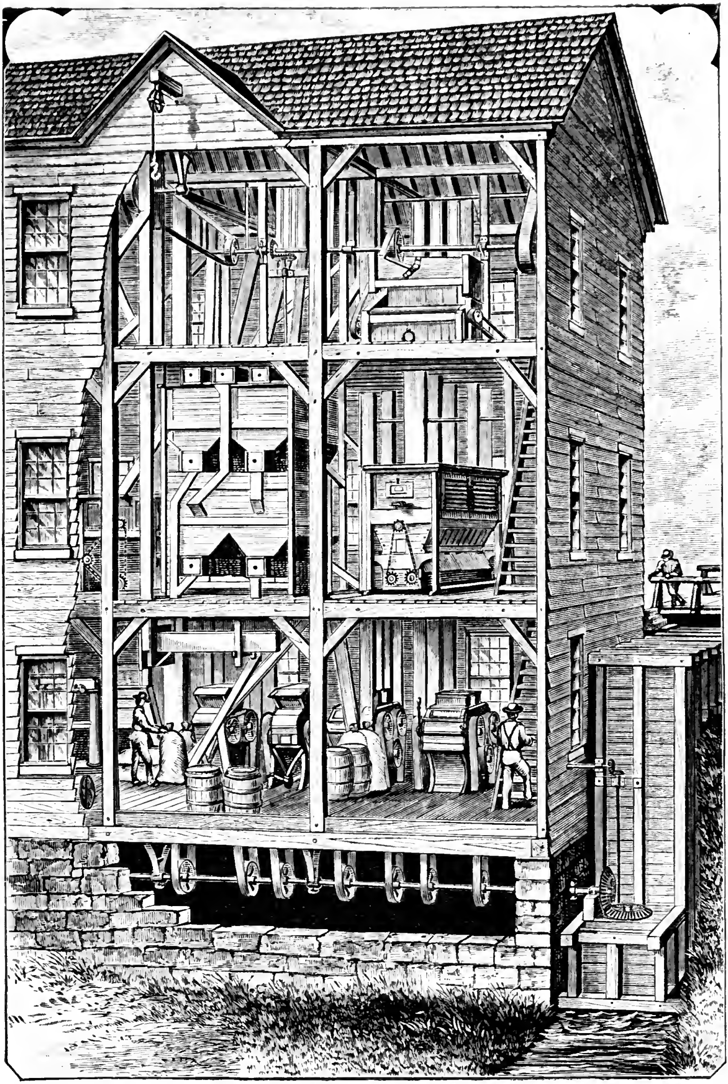
DEGRAFF, O., April 3, 1885.

Messrs. James Leffel & Co.:

DEAR SIRS:—Some two years ago I tore out my old overshot water wheel and put in its place one of your 30½ inch Turbine wheels. I am surprised at the wonderful amount of power in these wheels and I must say I am well pleased with the exchange. I can run my roller mill with all the machinery connected necessary to make three barrels per hour, with this 30½ inch wheel, with a two-thirds gate under a 16 foot head, no back water. I have also a 20 inch wheel to assist in time of back water. My experience is to place wheel at the bottom of penstock, as I can get more power than when there is a flume below the wheel, (except in back water) but such times only come occasionally and I use both wheels and get all the power needed. I can cheerfully recommend you to any one desiring a water wheel as honest and responsible men with whom to deal.

Yours truly,

MAT WOLFE.



Hudson River Paper and Pulp Co. Water Wheel House.

The cut on opposite page, shows one of the wheel houses of the above Co., containing 10 Leffel water wheels on horizontal shafts. Each of the large cylindrical cases encloses two wheels, on steel shafts $8\frac{1}{2}$ inches diameter, and so arranged as to discharge the water into one draft tube, situated between each pair. The same company are using 5 more Leffel wheels in other parts of their works: consisting of paper, pulp and saw mills. This company's plant is producing daily, 12 tons of paper and about 40 tons wood pulp, dry weight. The following letter from the superintendent will further explain.

FIFTEEN LEFFEL WHEELS GIVING 6,000 HORSE POWER.

PALMER'S FALLS, Saratoga Co., N. Y., May 11, 1885.

MESSRS. JAMES LEFFEL & Co., 110 Liberty St., N. Y.

GENTS—In reply to yours of the 6th inst., asking "how our new wheels worked under the conditions we placed them," would say that we have no fault whatever to find with them; in fact they are doing more work with less water than we calculated on, that is, the two sets or runs we put in and started last October (1884). They have been running almost constantly day and night since, and we have only had occasion to look at them once since, and that was for the purpose of clearing out some blocks of wood that got in the canal below the rack.

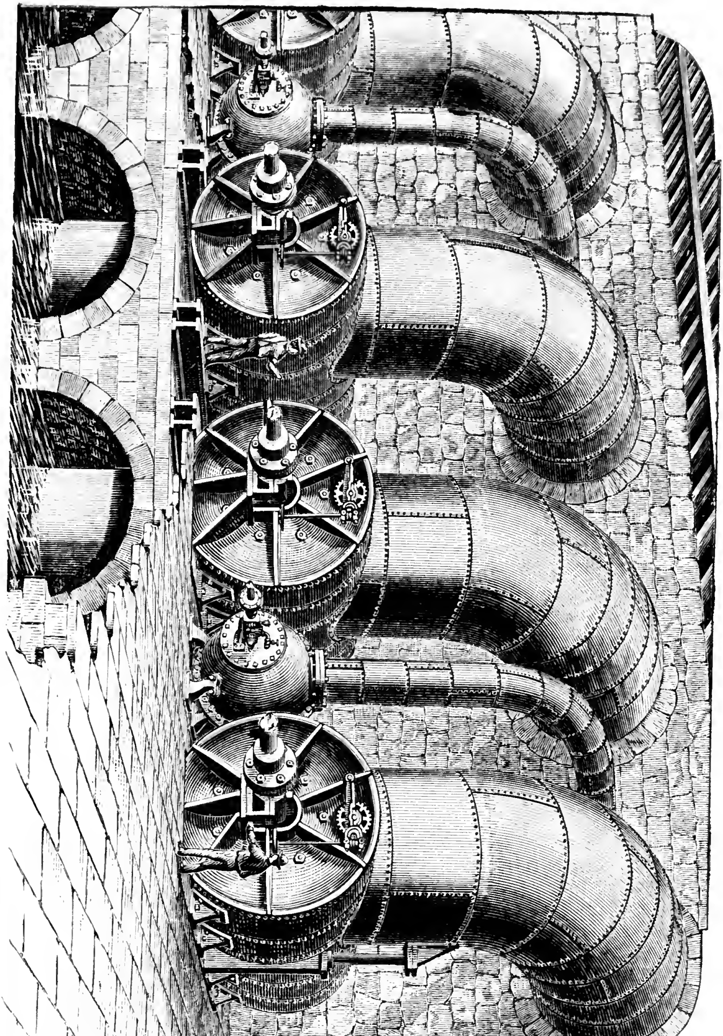
As we knew of no similar work, or any of such magnitude as a precedent to go by, we naturally gave the planning of our motive power and connections a great deal of thought and study, and after looking over the various turbine wheels of different builders we decided on yours as having the greatest number of good points in its favor, and the satisfactory working of the two runs as mentioned, confirms us in our conclusions.

After running the two sets (1100 to 1200 horse power each) day and night for six months, we were so well satisfied with the results that we have erected two more sets, exact duplicates of the first two in every particular. We had a pratical illustration that we studied very closely while in actual operation, and could not find a single point in any of the details that we thought we could change or alter to advantage.

We expect to get the new wheels and machinery running next month; when we will have about 5,000 horse power in that mill alone. These wheels, cases etc., are all contained and the power consumed in a room 70 by 80 feet, without the use of gearing or belts.

You probably are aware that you made a very nice fit of the wheels to their cases. There was not over one thirty second of an inch difference in the diameters, yet in all the wheels we have placed on a horizontal shaft not one has rubbed against the case; there being no difficulty in adjusting and keeping them in place.

Our wheels in the Pulp mill are placed twenty feet above the tail water; rather the bottom of the draft tube is twenty feet below the center of the wheels, and the water in the wheel pit stands one to two feet above the bottom of the tubes, making a column of water 18 to 19 feet in hight hanging below the center of the wheel shaft. We have a vacuum gauge attached to the top of draft tube which indicates 16 to 18 inches of Mercury, showing that we lose nothing to speak of by placing the wheels on horizontal shaft, and above the discharge water. Calling the specific gravity of the mercury 13.6, our gauge shows that the water in draft tube stands above the center of shaft.



In the Fall of 1883 we placed two of your special size and build 44 inch wheels on our lower level, on a horizontal shaft under 28 feet head and they have been working day and night ever since. They replaced a 60 inch wheel on an upright shaft. The old wheel was not able to drive half our present machinery up to speed on full work. These new wheels drive everything up briskly and not using full gate. We measured the water from old wheel and that used by your two 44 inch and found the latter using considerable less water and giving us ample power. Formerly, steps and gears bothered us greatly, now we have neither step or gears.

We have now fifteen of your wheels (all except one 23 in.) working on horizontalshafts, giving us nearly 6,000 horse power. We have ten wheels of other makes giving about 1,500 horse power, and from our present experience when the proper time comes we will replace the latter with your wheels.

Yours truly, WARREN CURTIS,
(Supt. Hudson River Pulp & Paper Co.)

Directions for Setting the Leffel Wheel.

We have endeavored in the following article to give a few rules embracing the vital principles to be observed in putting in our wheel. These rules are stated as plainly as possible, in order to avoid any misunderstanding in their application ; and if they are carefully followed the wheel cannot fail to work as represented by us.

THE MILL DAM.

In improving a water privilege, the first step is the construction of the dam. For full and minute information on that subject, covering every variety of circumstances and form of dam, we would refer the reader to the columns of THE LEFFEL MECHANICAL NEWS, (published by James Leffel & Co., Springfield, Ohio,) in which a long series of original articles on Mill Dams and their construction was published, each article being illustrated with a large original cut. We would refer parties also to "Leffel's Construction of Mill Dams and Bookwalter's Millwright and Mechanic," a nicely printed and bound book, finely illustrated throughout with full page cuts, and published also by our firm. It contains all that has appeared in the MECHANICAL NEWS, (much of which having been revised), as well as considerable that has not been published in that paper.

THE HEAD RACE AND GATES.

The next matter to be attended to is the canal or head race, in constructing which a very frequent error is committed in failing to give it sufficient capacity. It should be made both wide and DEEP; and this is especially necessary where the race is of considerable length and a large quantity of water is to pass through it. It is difficult to give a definite rule which will apply to every case, but it may be stated as a general rule that the water should not flow faster than from 60 to 120 feet per minute. In cases where there is a long race, after the wheel has been running three or four hours, the head frequently draws down from one to three feet. The effect of this is precisely the same as if the dam had been lowered an equal distance, resulting in a loss of power which would have been prevented by making the race as wide and deep as it should be. On page 108 will be found useful hints on the subject of head-gates, their construction, etc. "Leffel's Con-

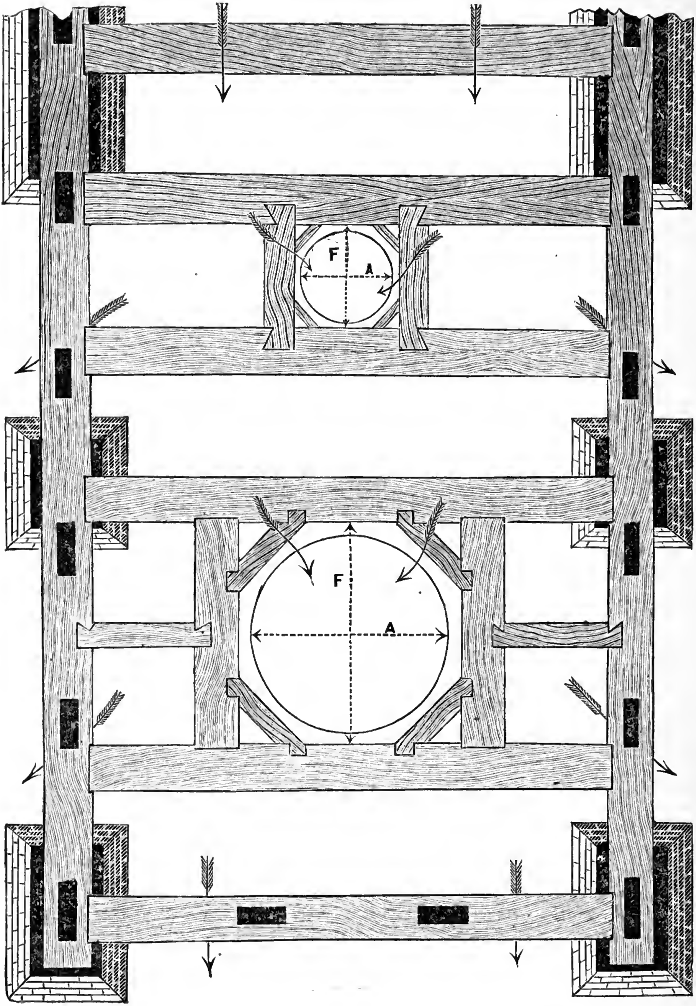
struction of Mill Dams," already referred to, contains much more on the subject, race and reservoir embankments, etc., which can be made available in the improvement of any water power of any kind.

THE WHEEL PIT

must next be located, and we can not too strongly impress the importance of a proper depth of the pit. This is a point in which millowners and millwrights putting in our wheel are more liable to err than in any other. In fact, if a person should write us, "Your wheel is not doing as represented," the first question we would ask is, "What depth have you below the wheel?" Whether under high or low head, the pit should be made deep and wide. There is no case where this is more important than where a large wheel is run under a low head, as under these circumstances no loss of head, however small, can be afforded. A pit of insufficient size causes the water to react upon the wheel; and an additional loss of power is also caused by the fact that a portion of the head is consumed in forcing the water out of the pit when there is not sufficient outlet. As a general rule, the depth of pit should not be less than 20 inches for the smallest wheels, and in some cases as much as 5 or 7 feet for the largest wheels under high heads. An average size wheel, say a 48-inch, under an average head, say 12 feet, should have 33 to 40 inches clear space from the mouth of the cylinder or wheel tube, where the water discharges from the wheel, to the bottom of the pit. In making the pit, if there is a sandy or mud bottom, to keep the foundation from washing out, mud-sills must be put down as shown in plates on pages 26 and 87, and on these sills should be placed a 2½ inch plank floor. The tail-water should stand *at the very least*, two feet deep on this floor when the wheel is not running; and for high heads and large wheels it should not be less than from three to six feet, the cylinder or draft tube of course in all cases touching the tail-water. A rock-bottom does not require mud-sills or plank, but must be blasted out so as to give the same depth of standing tail-water. This depth should be continued the whole length and breadth of the flume, and, if possible, from two to four feet beyond the sides; but in all cases it must extend from five to twenty feet down the tail race from the end of the flume. We wish to most strongly impress the fact that the water can not discharge too freely from a wheel.

THE TAIL-RACE,

as well as the wheel pit, should be both wide and deep; and, if possible, the level, or the bottom of the wheel pit, should be carried out the whole length of the tail-race to the stream, which is easily done when the race is short and empties directly into the stream. When the desired depth can not be given the whole length of the race, it should be made up in width; and in this case the bottom of tail-race should slope gently to the bottom of the wheel-pit, in order to avoid an abrupt opposing surface. There should be, if possi-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ble, two feet in depth of dead water in the tail-race when the wheel is not running, in order to avoid the raising of the water in the tail-race, and consequent loss of head. The race should also be much wider than it is usually made; and its sectional area should not in any case be less, but should if possible exceed that of the outlet of the wheel pit. By the sectional area is implied the product of the width and depth multiplied together. A wheel pit three feet deep and ten feet wide has thirty square feet sectional area. It is of as much importance that the tail-race should be made wide and deep as that the head race should be, and neither can be made too large.

SIZE OF PENSTOCK.

We have given in column B, on pages 27 and 29 the inside diameter of penstock for each size wheel, and by reference to the plate on the opposite pages (26 and 28) the required diameter can be readily found. These are the least dimensions which it is expedient to employ.

SIZE OF FLUME OR CONDUIT.

As we have already stated, the flume or forebay conducting the water to the penstock, should be sufficiently large to deliver the water smoothly and quietly in the penstock without loss of head. The water in the penstock, in order to give the best results, should be as nearly as possible without motion, except the natural current or suction towards the wheel. In order that there may be no mistake as to the size of the conduit, we have given in last column on pages 27 and 29, the cross-section of water in conduit. [The space in conduit above the surface of the water is not included in this estimate.] For example, a 40-inch wheel should have a flume, according to the table to which we have referred, of about 34 square feet, or a depth and width of water 54 by 90 inches, or 4½ by 7½ feet, which, multiplied together, gives the square feet or cross section; therefore, a flume or forebay 4½ feet deep and 7½ feet wide would be as small as it should be made; and to this should be added one foot in height for the space above the surface of water in the conduit.

CONSTRUCTION OF LOWER TIMBERS AND FLOOR OF FLUME.

These cuts on pages 116 and 119 are designed to give our customers a general idea of the proper manner of framing the bottom of penstocks for our wheels. We do not anticipate these plans will cover a great number of difficult places in which our wheels are frequently used; but they will give the millwright or mill-owner a good insight of the method in which the timbers immediately around the cylinder of the wheel should be framed. A number of other ways by which the bottom of the penstock may be framed to suit certain locations, will readily occur to a practical mill-wright.

In no case should light, weak timbers be used for the bottom of

penstocks. The side sills should be 12 inches square, providing 10 inch square posts are used, which will be heavy enough for 10 to 15 feet head. For 12 by 14 inch sills, 12 inch posts may be used. If the corner posts are rabbeted, they should be 12 by 14, or 14 by 16 inches square, so as to rabbet four inches one way and two inches the other. The intermediate sills may be narrow one way and placed edgewise up and down; and in large flumes these may be supported by two or three posts of stiff, hard timber, four inches square, placed solidly on the foundations. Letter F, in plates on pages 27, 29, 116 and 119 shows the distance the timbers should be framed apart, around the cylinder. In column F, page 27, will be found the distance, in inches, that these timbers should be framed apart for each size of wheel. For the size of penstock, see the foregoing articles on that subject.

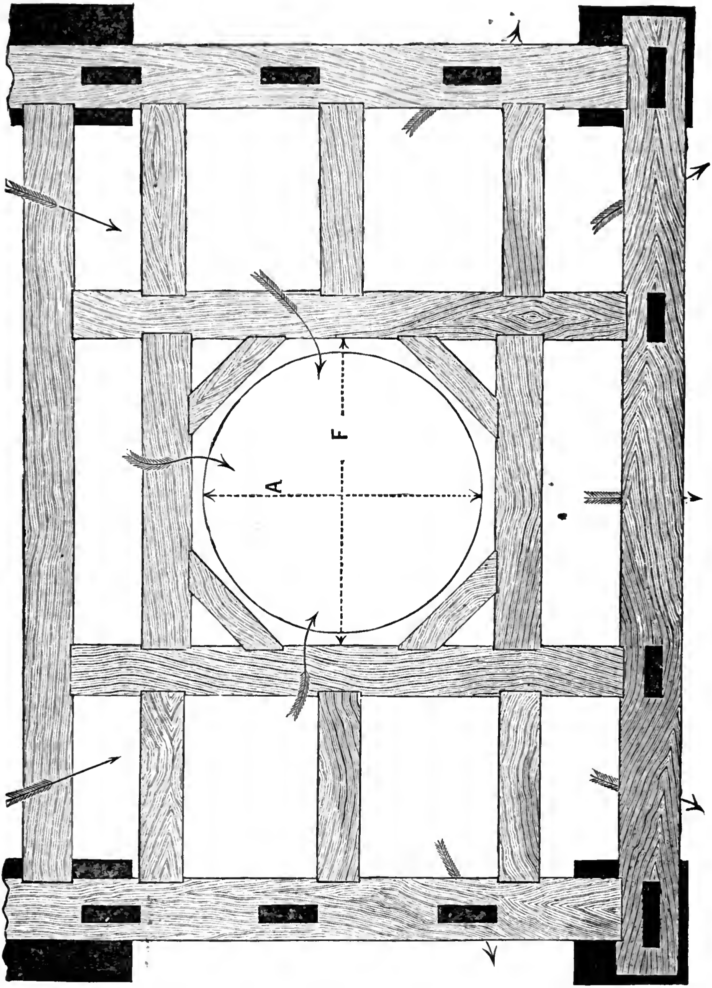
In plates on pages 87 and 77, we show the penstock resting on stone piers. This is not absolutely necessary, as the side posts of the penstock can extend down to the apron or bottom of pit, the lower ends of the posts resting on mud-sills where the bottom is mud or sand (with the sills of the penstock framed into the posts,) or on rock if the bottom is of that nature. This arrangement is used in plate on page 96.

In the case of large penstocks, we would advise that they should rest either on stone pillars or side walls; but pillars are decidedly the best, especially where the tail-race or wheel-pit can be made wider than the penstock, as they allow a free discharge of water in all directions.

For the floor of the flume, 2½ to 3 inch planks should be laid on the sills of the penstock and spiked down. A hole must be cut in this floor, of sufficient size to allow the cylinder of the wheel to pass through. The diameter of this hole is given in column F, page 27. Surrounding the hole, soft pine planks should be placed, extending a little beyond the flanges of the wheel, and beveled as shown on pages 26 and 28. These planks must be leveled and planed off perfectly true. The flange of the wheel rests upon the planks, the cylinder passing down through the hole, and its end dipping two or more inches below the surface of standing tail-water. No fastening is necessary to keep the wheel in position, as its own weight and the pressure of the water will hold it firmly in place.

OPEN PENSTOCK FOR LOW HEADS.

Where there is a low head, a plain penstock is sufficient, as shown in the plate on page 77. The wheel pit, bottom timbers and floor of flume are to be made as above directed. Where the flume is not too high, it is desirable that the floor of the forebay should be on a level, or nearly so, with that of the flume, as shown in plate on page 106, freer passage into the flume being thus afforded to the water. The penstock should be plain, substantial, and constructed according to the dimensions given in columns B, in table of dimensions on pages 27 and 29, and clearly shown in plate on pages 26 and 28. The corner posts should be in low flumes, 10 by 12 inches; in medium size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and high flumes, 12 to 14; and in very high flumes, 14 by 16. They should be rabbeted 4 inches one way and 2 inches the other. The other posts should be 8 by 10, 10 by 12 or 12 by 14 inches, corresponding to the size of corner posts above stated, and from three to four feet apart, according to the size of plank used—as the heavier the plank the further apart the posts can be placed. No particular kind of flume is required. It can be constructed to suit the peculiarities of the location; the only essential points being to make it large enough and sufficiently strong, and the wheel-pit and conduit of such size as to give free entrance and discharge to the water.

DECKED PENSTOCKS.

There are a large number of mills so situated that the power is required to be taken off from the water wheel shaft below the level of water in head-race. In such cases, the wheel can be put in as shown in plates on pages 96, 87 and 84. The floor of penstock, wheel-pit, etc., should be constructed as shown in the foregoing articles on "Wheel Pit," "Size of Penstock," and "Construction of Lower Timbers and Floor of Flume." In addition to the ordinary perpendicular portion of the penstock, the construction of which has been described in the article on "Open Penstocks for Low Heads," there is a horizontal portion built out, the top of which is covered or decked; it being below the point where the power is required to be taken off. The water wheel shaft and gate rod pass through this deck or cover, and around each of these iron stuffing-boxes are placed so as prevent any leakage ot water around the shafts. We make these stuffing-boxes to order. In case where lack of time or oher reason they can not be conveniently procured, the millwright can construct wooden ones which will answer the purpose. The timbers in this decked extension should be as strong and substantial as those in the main body of the penstock; and a few bolts put in at suitable points, as shown in plate on page 87, will repay their cost. Thewheel-shaft should be placed as near the main penstock as the nature of the gearing will allow. By comparing plates on pages 96 and 87, this point will be readily observed; and by acting in accordance with it, the space will be economized, and in many cases the construction of a greater length of decked flume than is necessary will be avoided.

We wish millwrights to note particularly the manner in which the intermediate sills supporting the floor of the penstock are hung to the main cap by means of bolts in plate on page 87, and to the lower timber in plate on same page. We highly recommend this plan, as the main sill is thus kept from obstructing the free discharge of water, while the stone piers also admit of a free escape of the water in all directions, as well as affording a good foundation for the whole structure; of course the stones should be well shaped and laid up in order to withstand so great a weight. The decked portion of the penstock may be extended into the mill to any desired length, by whith means the wheel can be brought directly under the machinery.

The advantage of this arrangement is that it avoids a waste of power by bringing the wheel and machinery as near together as possible and dispensing with a long train of gearing.

THE FOREBAY RACK.

It is *highly important* that the rack across the race or forebay should be properly put in and attended to. The bars should be enough apart not to obstruct the flow of water, and should be kept clear of all trash ; many inches of head are lost by this neglect, and often the efficiency of a wheel is impaired by the same cause. Proper attention given to this matter will repay well.

It is a good plan, and we would recommend it in all cases, to put in a coarse rack, several feet above the rack just mentioned ; the coarse rack will serve to retain the coarser drift, and thus avoide the necessity of frequent removal from the fine rack. The spaces of the coarse rack may be twice as large as the fine ones are. It is also advisable to cover the entire forebay with boards from the last rack towards the wheel and over it especially where small wheels are used ; such precaution will prevent rubbish from dropping or being thrown into the water and getting in the wheel.

DRAFT TUBE.

In adapting wheels to very high falls, it sometimes becomes desirable, in order to avoid extreme length of shaft on wheel, and also to otherwise conform to the pecular location of the mill, to place the wheel at a distance above tail-water and conduct the water away from the wheel by an *air-tight* tube called a Draft Tube. It is also desirable in some cases, when the outlet is cramped, to employ a short draft tube, say of two or three feet length, thus bringing the lower timbers of the penstock up from the water, and allowing a free discharge, and likewise affording a greater convenience in getting at the wheel. There can not be, ordinarly, any objection to the use of a draft tube not to exceed ten feet in length, as within that limit, by good workmanship and proper material, a tube can be constructed both air-tight and durable ; yet, as a want of experience in this matter might lead to mistakes, which would tend to greatly diminish the power of the wheel, we would here state that as a rule we would advise the wheel to be placed at the bottom of the fall. When the draft exceeds ten feet in length, and particularly when used for small wheels, it should be made of boiler iron, gotten up in the most thorough manner, perfectly steam-tight, as our experience has taught us that when the tube is of great length, a wooden tube can not be relied on as either water-tight or durable.

On page 55 will be found a plate illustrating the use of the draft tube. The end of the draft tube should dip two or three inches below the surface of standing tail-water. The same care is necessary in making the wheel pit, when a draft tube is used, as when a wheel is put in without the tube. For information on this point, reference should be made to the foregoing articles on that subject.

A Beautiful Exhibit at the Smithsonian Institute.

The following is from the " Mechanical News," of New York City. Among all existing agencies for the diffusion of useful knowledge whether maintained at public expense or by the generosity of individuals , there is none which has a wider or more honorable fame, at home or abroad, than the Smithsonian Institution at Washington. For nearly forty years its name has been a household word among our people. Recently the managers of the Institution have undertaken the addition of a new and eminently interesting feature. Its design, to describe it in general terms, is to present in all the leading branches of mechanical and manufacturing industry examples on the one hand of the old, crude and primitive appliances which exist as a relic of the past age, and on the other the most approved specimens of American machines or devices which those arts in their modern atate afford. To do this intelligently is a task requiring no small amount of patient investigation, and the exercise of sound, skilful and strictly impartial judgment. The instructive character of such an exhibit will be readily comprehended by the reader. By the professional workman in any given department of industry it will of course be most fully appreciated. In that branch of industrial science which comprises the utilization of the power of water, the managers of the Institution have selected the James Leffel Double Turbine as the representative modern American water wheel, embodying the most improved and efficient means for the development of water power as applied to the propulsion of all kinds of machinery. To this end they requested the firm of James Leffel & Co., to furnish them a specimen of the Leffel Wheel to be placed in the new National Museum building lately completed, adjoining the original structure of the Institute, where it will form a part of the collection of the best modern machinery which is now being formed on the plan above described. This collection, it will be understood, includes but one machine or article of manufacture in each branch of industry comprised· The selection of the Leffel Wheel as the sole representative of the highest standard of exeellence attained in that line is therefore justly a matter of pride to its makers.

The wheel asked for by the Smithsonian Institution has been made at the shops of James Leffel & Co., in Springfield, Ohio, and is now at their office at 110 LibertyStreet, New York. It is not a " model " merely, but a working wheel of 7⅝ inches diameter, one of the regular sizes made by the firm. It differs in no respect from those of their ordinary make, save in its ornamental finish, upon which special care has naturally been bestowed. The gates and gate-rods are plated with pure gold, and the other part of the casings with silver of like quality. In its workmanship, as well as in the principles of its construction and operation, which belong to it in common with all sizes of the Leffel Wheel, from a diameter of 6⅝ inches to 87 inches, it will constitute no unworthy feature of the myriad collection of the best products of modern skill and invention which the managers of the Smithsonian have gathered within its walls.

Centennial Exhibition and Smithsonian Institute.

Upon due examination and consideration, the Commissioners of the Centennial Exhibition at Philadelpha 1876, awarded the Leffel wheel a Medal, a Diploma, and an honorable mention as to workmanship, design, general merits etc.

The Leffel Wheel has also recently been selected by the Smithsonian Institute, as representing the highest state of the art in the manufacture of practical turbines.

We received also a Certificate and a Diploma of Award at the great International Cotton Exposition in 1881 at Atlanta.

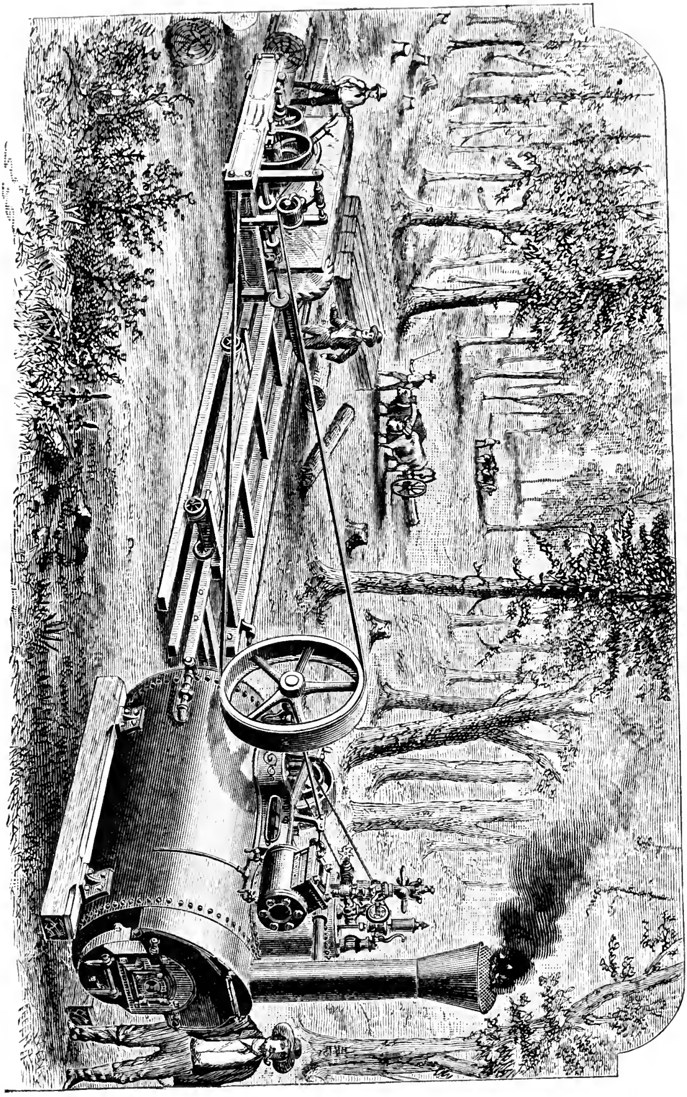
We might add that the Leffel Double Turbine received awards, Diplomas, and Medals, not only at the Centennial and International Exhibitions, but from time to time have received First Premiums, Awards and Diplomas in every state of the Union wherever Fairs and Exhibitions have been held.

12,000 Leffel Wheels Successfully Operating, giving over 600,000 Horse Power.

Over 20 years in operation has proven its durability and practical adaptation to every purpose. The enormous number of our wheels used, and the unanimous praise accorded them, should be sufficient evidence that a party is trying no experiment in putting in a Leffel wheel. Heretofore we have been publishing a large list of names of parties using our wheels, some companies using as many as 27.

To print a complete list, even in the smallest type and most condensed form, would require a book of near the same size as the present edition of phamplet. Our book for 1873 of 160 pages, contained some 67 pages of references. Although in later editions we have published a large and greatly condensed list, it would require much more space than formerly to give a complete list, especially in consideration of the very large number that we have sold during the past 12 years, or since 1873, when a list at that time covered 67 pages. We therefore omit the list from the present edition, but will be glad to supply parties at any time references in any part of the country.

This edition of pamphlet contains also only a few of the new testimonials in our possession, having a large number on file that we are unable, for want of space, to make public.



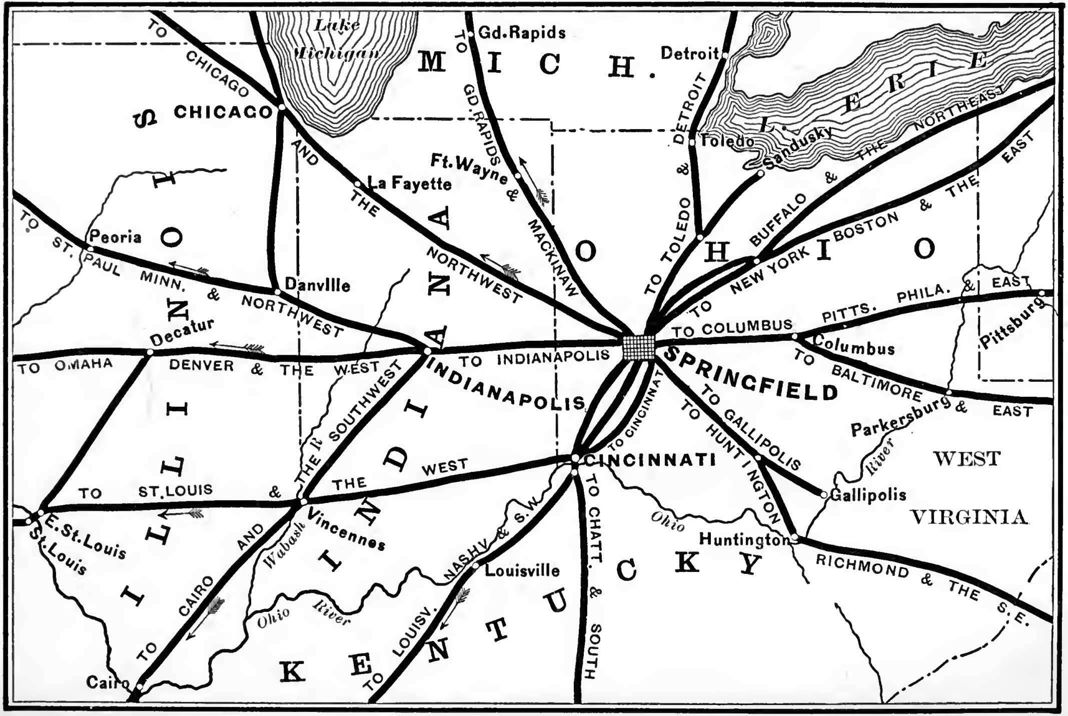
Water Wheel Governors.

We are prepared to furnish, at short notice, Governors of the most approved patterns for regulating our wheels, at the manufacturers prices. Our large experience in the introduction of the Leffel Turbine, and its application to all sorts of purposes, especially where the work to be done is intermittent and irregular, together with the manufacture of Governors, has afforded us opportunity to acquaint ourselves with the various machines in that line now in the market. At the same time it has been our object also to obtain those of the greatest efficiency, and from which the best results might be expected, as frequently they afford aid to the successful operation of wheels. We will take pleasure at any time in offering any advice when called upon as to their attachment to Turbines, and as to styles that may in different cases prove most satisfactory, whether the purchase is made of us or not.

Shipping Instructions and Facilities.

It will be seen by an examination of the map, which we have specially prepared and published on page 127, that our facilities and advantages for shipping are unusually good. There are several trunk lines running on either side of our shop, which will also be found by examination of the engraving of our works on page two. These connect with all the various trunk lines and branch lines running through our city, since it is a great railroad center, enabling us thereby to deliver abroad the cars free of freight, drayage or other incidental charges to which shippers are frequently subjected, who are not thus favorably located. It ought not be forgotten by purchasers, that often these charges, such as drayage, cartage and delivery to depots, is a considerable item of expense; and while they are not mentioned frequently by manufacturers who have not these facilities, such expense charges will often be found in invoices or bills rendered by such parties to the customers. We have direct lines east, west, north, south, south-east, north-east, north-west, either to the Atlantic or Pacific, or to the Gulf; and can obtain and contract, by the large railroad competition that is afforded, the lowest possible shipping rates of freight to our customers.

We cannot impress too strongly the necessity of each customer ordering a wheel, of giving us some instructions as to what road. or route he may desire the machinery shipped over in reaching its destination. Usually, we understand the best route by which the goods should leave our city; but in transfers that sometimes occur near the destination, the customer may have some preference as to the particular branch or road which should have care and charge of the shipment on its arrival or at its destination. Sometimes there may be two or three railroads at or near the place, where the shipment is desired, with which we may not be as fully acquainted as the customer; in which case his advice as to the particular branch over which he wishes to receive it, will be of importance to us.


MICH.
OHIO
INDIANA
ILLINOIS
KENTUCKY
WEST VIRGINIA
Lake Michigan
L. ERIE
Ohio River
Wabash
SPRINGFIELD
CINCINNATI
INDIANAPOLIS
CHICAGO
Gd. Rapids
Detroit
Toledo
Sandusky
Ft. Wayne
La Fayette
Peoria
Danville
Decatur
Columbus
Pittsburg
Parkersburg
Gallipolis
Huntington
Louisville
Vincennes
E. St. Louis
St. Louis
Cairo
TO CHICAGO AND THE NORTHWEST
TO GD. RAPIDS & MACKINAW
TO TOLEDO & DETROIT
TO BUFFALO & THE NORTHEAST
TO NEW YORK BOSTON & THE EAST
TO COLUMBUS PITTS. PHILA. & EAST
TO BALTIMORE & EAST
TO GALLIPOLIS
TO HUNTINGTON
RICHMOND & THE S.E.
TO CINCINNATI
TO CHATT. & SOUTH
TO LOUISV. NASHV & S.W.
TO CAIRO AND
THE R SOUTHWEST
TO ST. LOUIS & THE WEST
TO OMAHA DENVER & THE WEST
TO INDIANAPOLIS
TO ST. PAUL MINN. & NORTHWEST